TUGAS AKHIR – TI 141501

ANALISA KEBUTUHAN UNTUK *AIR CONDITIONER* PADA SEKTOR PUBLIK PEMERINTAH KOTA SURABAYA

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Surabaya 2016

FINAL PROJECT – TI 141501

NEED ANALYSIS FOR AIR CONDITIONERS IN PUBLIC SECTOR OF SURABAYA CITY GOVERNMENT

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APPROVAL SHEET

NEED ANALYSIS FOR AIR CONDITIONERS IN PUBLIC SECTOR OF SURABAYA CITY GOVERNMENT

FINAL PROJECT

Submitted to Qualify the Requirement of Bachelor Degree
Department of Industrial Engineering
Faculty of Industrial Technology
Institut Teknologi Sepuluh Nopember
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ABSTRAK

Air conditioner (AC) mengonsumsi energi paling banyak pada tipikal bangunan dibanding dengan sektor lain. Hal tersebut membuat manajemen AC menjadi dibutuhkan dan penting untuk mencapai pemakaian energi yang efisien. Kondisi cuaca yang sangat panas dan lembab menyebabkan sebagian besar bangunan di Surabaya menggunakan AC, termasuk bangunan kantor Pemerintah Kota Surabaya. Akan tetapi, tidak ada petunjuk maupun peraturan bagaimana cara mengelola AC di Pemerintahan Kota Surabaya, padahal Surabaya memiliki tujuan untuk menjadi *green-eco city*. Evaluasi kondisi eksiting dari penggunaan AC di Pemerintah Kota Surabaya pun dilakukan. Evaluasi dilakukan pada bangunan kantor satuan kerja atau biasa disebut SKPD. Hasil evaluasi menunjukkan bahwa hampir semua AC mengalami *over capacity* dan tidak semua efisien dalam menggunakan energi. Oleh karena itu, analisa kebutuhan diperlukan oleh Pemerintah Kota Surabaya untuk dapat mengelola AC dengan lebih baik. Dengan menggunakan dua konsep yang berbeda, dibentuk dua prosedur analisa kebutuhan yang dapat digunakan untuk kondisi ruangan berbeda di Pemerintah Surabaya Kota.

Kata Kunci **:** *Air Conditioner, Green Building, GBAA Criteria, Analisa Kebutuhan*

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NEED ANALYSIS FOR AIR CONDITIONERS IN PUBLIC SECTOR OF SURABAYA CITY GOVERNMENT

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ABSTRACT

In typical buildings, air conditioners have the biggest percentage in energy consumption among all sectors. It makes a good management for air conditioners is needed and important in order to use the energy efficiently. Having a very hot and humid weather, it gives impact that most of buildings in Surabaya installed air conditioners, including Surabaya City Government office buildings. However, there is no regulation nor guidance how to manage air conditioners in Surabaya City Government, while Surabaya itself has a goal to become a green-eco city. Then, the existing condition of air conditioners usage in Surabaya Government units (SKPDs) is evaluated. The evaluation resulted that most of air conditioners were over capacity and not all of them were efficient in energy consumption. Therefore, a need analysis is required to help Surabaya City Government managing its air conditioners better. By applying two different concepts, one is based on the architectural view and another one is based on green building criteria, the existing condition is analyzed and two procedures of need analysis are produced. The procedures can be implemented for two different conditions of office building rooms in Surabaya City Government.

***Keywords** : Air Conditioner, Green Building, GBAA Criteria, Need Analysis*

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CHAPTER I
INTRODUCTION

In this chapter, it will be explained about background, problem formulation, objectives, benefits, scope of the research, and writing structure of this final project.

1.1 Background

Environmental issue is the current topic in the world nowadays. Environmental impacts are always considered together with the rapid development in many sectors. It is occurred because the development such as the population growth, the technology advancement, or the expansion of business, will always be related to energy consumption and give impact to the environment. The development of a country also sometimes be defined by looking at the infrastructure improvement and the increase of urban buildings.

According to United Nations Environment Programme (UNEP), buildings consume about 40% of global energy, 25% of global water, and 40% of global resources. It is also approximated that residential and commercial building consume 60% of the world's electricity. It is a large number since it exceeds the half of the usage of electricity in the world. In Asia, building sector is also one of the biggest contributors to total national energy consumption (Annalia, 2015). Moreover, most of countries in Asia are developing countries which means that the number of buildings will keep increasing along with the development of the country. It will definitely affect to the increase of world energy consumption. In Indonesia, 20% of energy consumption is spent for buildings and every year, there is approximately 7% acceleration rate of the energy consumption (Priatman, 2016).

Not only they contribute a lot for the energy consumption, but buildings also emit about one-third of greenhouse gas emissions in the world. As it can be seen on Figure 1.1, buildings have the highest percentage, which is 38%, as the contributor of GHG emissions from fossil fuels. The number is more than both the transportation and industrial sectors which are known clearly producing emissions. The emissions of buildings come from the combustion of fossil fuels to provide heating, cooling and lighting, and to power appliances and electrical equipment (USGBC, n.d.).

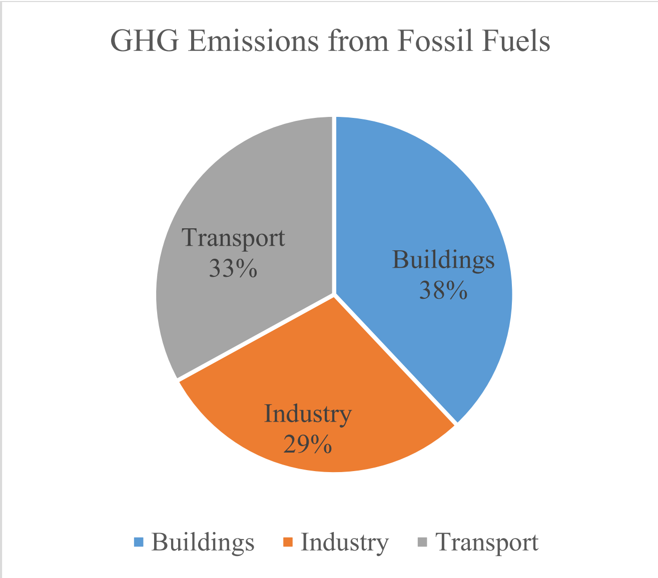

Figure 1.1 Contributors of GHG from Fossil Fuels (USGBC, n.d.)

In addition, buildings have a lifespan of 50-100 years. It is really a long time range for buildings to continually consume energy and produce emissions. It is also inevitable that buildings will always develop and increase in number in the future. With the current condition that energy resources are limited, the building growth will accelerate the use up of energy resources in short time. Therefore, the sustainability for building is really needed because it will affect significantly to the energy consumption in the world.

Sustainable building, or is commonly known as green building, is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a life cycle of building (EPA, 2016). (Priatman, 2016) stated that green building is specifically a design structure that reduces overall negative impact that is caused by the built environment. From those definitions, green building has strength in environmental and energy aspects compared to common buildings. By applying this green building, there are a lot of savings that can be occurred. Green building is estimated to have rate of energy savings of 30%, carbon savings of 35%, water use savings of 30-50%, and waste cost savings around 50-90% (Clevenger, 2008).

Green building was formally begun in 1990s and after that, there were a lot of organizations built in many countries to develop this green building concept. For example, there are United States Green Building Council (USGBC), Japan Sustainable Building Council (JSBC), Malaysia Green Building Confederation (MGBC), and Green Building Council of Indonesia (GBCI). These are non-profitable organizations which are also members of World Green Building Council (WGBC) (Prasetio, 2013).

Green Building Council of Indonesia (GBCI) is a non-governmental and non-profitable organization that is fully committed in applying environmental practices and sustainable development (GBCI, n.d.). GBCI was built in 2009 and it is an emerging member of World Green Building Council (WGBC). GBCI uses a rating tool called Greenship to evaluate whether a building is decent enough to be certified for a certain level according to the green building aspect. In Indonesia, the implementation of this green building is still focused in Jakarta and the awareness of the green building generally is still low.

Surabaya, as the second largest city in Indonesia, is an industrial city that is always growing and improving. Being led and organized by a visionary city mayor, Surabaya has an objective to become a green eco-city. After implementing the initial step by building many public parks around the city, Surabaya wants to apply green building concept as the next step of becoming an eco-city. Looking at the city development, green building seems to become an urgency for Surabaya to be applied.

Eventually, in 2014, Surabaya City Government held Green Building Awareness Award (GBAA). It was aimed to increase the awareness of the building owners and residents in Surabaya about environmental issues caused by buildings. In this event, 177 buildings were rated and judged to choose 12 winners for 4 categories. Those categories were hotels, apartments, malls, and office buildings. The criteria that were used in GBAA were according to Greenship that has been adapted. After the GBAA finished, in 2015, the city mayor of Surabaya, Tri Rismaharini, mentioned that buildings in Surabaya have to follow green building principles. The city mayor also wanted that Surabaya government offices also implement this green building.

However, green building has many aspects that makes the whole implementation is quite complicated to be done directly at a time. Then, the implementation is narrowed into applying green building into the air conditioners usage. In a typical building, air conditioners have the most energy consumption. Based on Figure 1.2, energy consumption in a building is divided into 6 sectors, which are water, office equipment, lighting, kitchen equipment, miscellaneous, and HVAC (Burger, 2015). HVAC, which stands for heating, ventilating, and air conditioning, has the highest percentage among all. Thirty percent of this energy consumption spends for heating and cooling the rooms in building. It means that by managing the usage of air conditioners, it can reduce the energy consumption which is included in the green building principle.

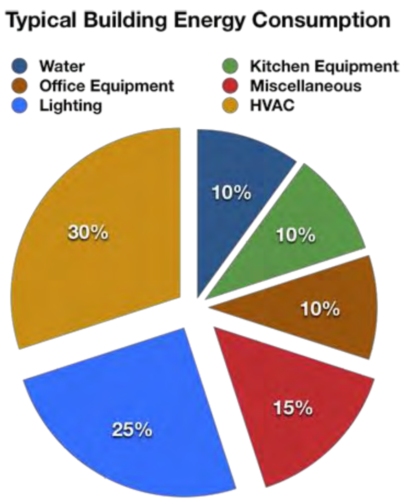

Figure 1.2 Energy Consumption Percentage in Typical Building (Burger, 2015)

In Surabaya, since the weather is really hot and humid, most of buildings must have air conditioners, including city government offices. Surabaya City Government has about 72 units, commonly known as Satuan Perangkat Kerja Daerah (SKPD), that help city mayor in maintaining the city. These 72 SKPDs are divided into 31 district offices and 41 official government offices and bureaus.

Most of these SKPDs offer public services to Surabaya citizens which makes the air conditioners usage increasing due to the increase of Surabaya population and the improvement of public services. The ownership of air conditioners per SKPD for 2005-2015 cumulatively can be seen in the Figure 1.3.

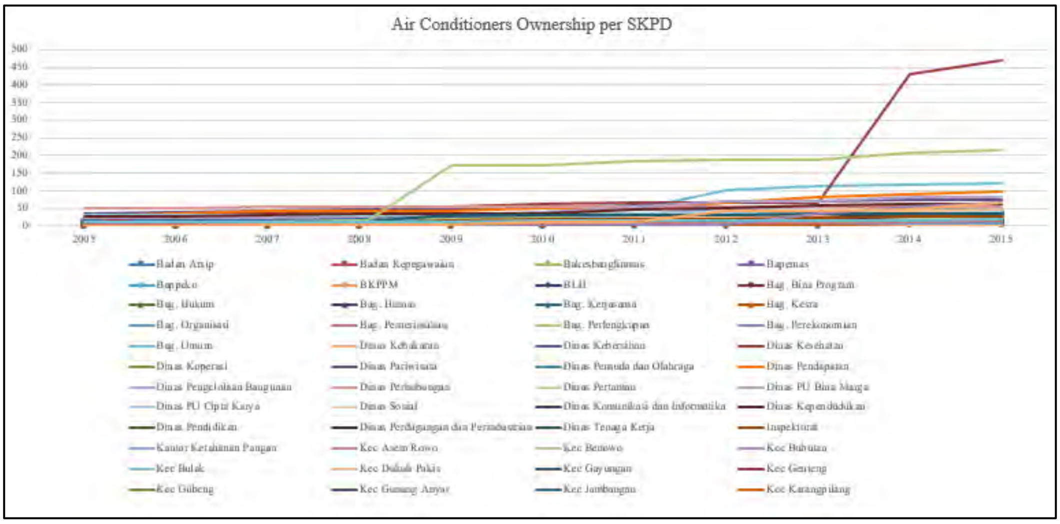

Figure 1.3 Cumulative Air Conditioners Ownership per SKPD (Simbada Surabaya, 2016)

From the graph 1.3, it can be said that the number of air conditioner always cumulatively increases even though it is not a drastic increase, only for certain SKPDs. It still implies that the number of air conditioner increases every year. Having around 20-100 air conditioners per SKPD, it is a large number for Surabaya City Government in managing numerous air conditioners. Therefore, the maintenance of the air conditioners is loose and the usage of air conditioners cannot be monitored well. The current management of air conditioners in Surabaya City Government needs to be evaluated and analyzed in order to implementing the green building concept. This research is conducted to evaluate the existing condition in order to develop the need analysis which is ideal according to green building. In the end of the research, a proposed methodology is produced as the guidance for Surabaya City Government in analyzing their need of air conditioners.

1.2 Problem Formulation

The problem to be solved in this final project is to conduct the need analysis of air conditioners in Surabaya City Government based on Green Building Awareness Award (GBAA) Criteria. Then, the existing condition is evaluated according to the ideal condition that has been designed based on that GBAA criteria.

1.3 Objectives

Objectives that are desired to be reached are listed below:

1. To analyze and evaluate the existing condition of air conditioners usage in Surabaya City Government according to the ideal condition with Green Building Awareness Award (GBAA) Criteria.
2. To determine factors that influence the need of having Air Conditioners in Surabaya City Government.
3. To propose a methodology of how the Surabaya City Government choosing air conditioner to support GBAA Criteria.

1.4 Benefits

The benefits of this final project are listed below.

1. Surabaya City Government will have a guidance to manage its air conditioners asset of its SKPDs based on GBAA Criteria.
2. To increase the environmental benefits by applying Green Building concept into air conditioners usage in government office buildings.

1.5 Scope of the Research

The scope for doing research in final project consists of limitation and assumptions as elaborated below.

1.5.1 Limitation

The limitation of this final project is that the research is only focused on office buildings. *Badan Perencanaan Pembangunan Kota* (Bappeko) is a government unit that is usually used for benchmarking by other SKPDs.

According to *Sistem Informasi Manajemen Barang Daerah* (SIMBADA), Bappeko is one of SKPDs that has increasing cumulative number in air conditioners. In addition, it is also where the pilot project of green building takes place. Therefore, this final project conducted the pilot study of green building at Bappeko office building located at Jalan Pacar No. 8, Surabaya.

1.5.2 Assumptions

The assumptions that are used in this final project are:

1. There are no changes in any government regulation during the research process.
2. All lamps in the room are turned on while the air conditioner is operating on work days.

1.6 Report Outline

The writing of this final project followed the outline with a brief description below.

CHAPTER I INTRODUCTION

This chapter contains about the initial information related with the final project, included background, problem formulation, objectives, benefits, research scope, and this report outline.

CHAPTER II LITERATURE REVIEW

This chapter presents about the theoretical and basic concepts to support the research. The theories and methods in the research are studied from a lot of literatures.

CHAPTER III RESEARCH METHODOLOGY

This chapter describes the stage of processes to conduct the final project, which also represented by flowchart. It shows the sequence of steps in doing the research in order to be systematic and structured.

CHAPTER IV EVALUATION OF EXISTING CONDITION

This chapter describes the existing condition of Bappeko related to the air conditioner usage and management which is supported by collected data. Then, the evaluation of the existing condition is also conducted.

CHAPTER V PROPOSED PROCEDURES FOR AIR CONDITIONERS NEED ANALYSIS

This chapter will present the methodology that is proposed to conduct air conditioner need analysis along with the details. It will be based on the evaluation that has been done for the existing condition.

CHAPTER VI CONCLUSIONS AND SUGGESTIONS

This chapter will present the conclusions produced by this final project and also the suggestions regarding the research.

CHAPTER II
LITERATURE REVIEW

This chapter presents all theories and concepts that support the research and these theories will be used as the references in doing the final project.

2.1 Green Building

Green building, or sustainable building, is one of the sustainable concepts which is focused on environment, energy consumption, quality of the work environment, financial effectivity, and global environmental issues (Prasetio, 2013). Green building is a holistic concept that starts with the understanding that the built environment can have profound effects, both positive and negative, on the natural environment, as well as the people who inhabit buildings every day. It is an effort to amplify the positive and mitigate the negative of these effects throughout the entire life cycle of a building (Kriss, 2014).

Green building concept is all aspects that cover the planning, design, construction, and operations of buildings with foremost considerations such as energy use, water use, indoor environmental quality, material section and the building's effects on its site. (Putra, 2006) elaborates some benefits of green building, which are:

- Reduce the operational cost

  This benefit can be gained by the efficiency of implementing green building as listed below, which are:

  a. Energy efficiency. The design of green building uses energy-saving technology which reduces the usage of heater and cooler until 60% and reduces the lighting usage until 50% of the building.
  b. Water efficiency. The change in water equipments, the change in water usage procedure, and the change in irrigation method can reduce the water consumption until 30% or more.
  c. The reduction of construction waste. Recycling of construction waste can make a significant saving and can create new economic opportunities.

- Reduce the cost of goods

  Green building applies the rehabilitation of existing buildings which can reduce infrastructure and material cost.
- Expand the time range in receiving investment profit

2.2 Green Building Awareness Award Criteria

Green Building Awareness Award (GBAA) is an event that was hold by DPUCKTR and BAPPEKO of Surabaya City. GBAA is the awarding event to give honor for buildings that are implemented green building principles (Faqih, 2014). It was initiated in April 2013 and was run in 2014. This activity has objectives that are divided into two, general objectives and specific objectives (Prasetio, 2013). The general objectives of this activity are:

- To increase the awareness and the knowledge of stakeholders (developers, building managers, building users, and community) about the importance of green building.
- To evaluate and measure the "greenship" of existing buildings in Surabaya City in the form of competition as the stepping stone of the next development. Greenship is the rating tools for Green Building certification in Indonesia.
- To compose the green building roadmap in Surabaya City based on the existing criteria.
- To compose the roadmap of quality and quantity improvement on green building in Surabaya City.

The specific objective of this activity is to support the vision of Surabaya City towards green eco city, where all Surabaya citizens are expected to contribute in using any resources efficiently and effectively for the sustainability in the future.

For this GBAA, some criteria are used to evaluate and rating the buildings in Surabaya City. These criteria are used for the self-assessment instrument model in GBAA. The GBAA criteria are actually the derivation of Greenship for Existing Building. Those major criteria are:

1. Appropriate Site Development (ASD)

2. Energy Efficiency & Conservation (EEC)
3. Water Conservation (WAC)
4. Material Resource and Cycle (MRC)
5. Indoor Health and Comfort (IHC)
6. Building Environment Management (BEM)

One criteria that is quite common in green building is energy efficiency and conservation. Because most of human activities need energy and the natural energy itself is becoming scarce. The energy efficiency in buildings has main indicator which is called Energy Consumption Intensity (ECI). ECI represents how much energy consumed (kWh) per meter square (m^2) every month (USAID, 2014). Based on Green Building Council Indonesia (GBCI), the standard ECI for office buildings is between 210-285 kWh/m^2/year.

In Minister Regulation about Energy and Mineral Resources No. 13 Year 2012, the value of the ECI can determine whether a building or a room is efficient in using energy. The ECI of office buildings with and without air conditioners are also differentiated. The standard of ECI for government office buildings can be seen in the Table 2.1 below.

Table 2.1Standard ECI for Government Office Buildings

Criteria	Air-conditioned Office Buildings	Non Air-conditioned Office Buildings
Very Efficient	< 8.5	< 3.4
Efficient	8.5 – 14	3.4 – 5.6
Less Efficient	14 – 18.5	5.6 – 7.4
Not Efficient	> 18.5	> 7.4

2.3 Need Analysis

Need analysis is the process of identifying and evaluating needs in a community or other defined population of people. The need identification is defined as a process of describing problems of a target population and possible solutions to these problems (McKillip, 1998). Need analysis focuses on the future, or what should be done, rather than on what was done as is the focus of most program evaluations. Therefore, sometimes need analysis is also called as needs assessments.

According to Government of South Australia (1999), the need analysis is really related in asset management. Asset management is a process to manage demand, guide the use and disposal of assets to make the most of their service delivery portential, and manage risks and cost over their entire life. There are three dimensions where strategic asset management can be considered, which are management levels, life-cycle functions, and organizational requirements. The need analysis is included in the dimension of life-cycle function which is covered the process from planning to the disposal.

There are some steps to conduct evaluation planning for the need analysis (McKillip, 1998).

1. Identify the users and uses for the analysis. For example, the employees in Bappeko who operate the air conditioners in their room.
2. Fully describe the target population and service environment. There are three levels of target population and their respective needs: Level 1 (Primary) targets are the direct recipients of the services; Level 2 (Secondary) targets include the individuals or groups who deliver the services; and Level 3 (Tertiary) involves the resources and inputs into the solutions.
3. Identify the needs where the problems and possible solutions are generated. This step shows the gaps between ideal and actual outcomes. The evaluation of existing condition is required to find the gap and in this research, it will be conducted based on the green building concept.
4. Conduct the needs assessment. The identified needs are evaluated which the most important need and whether there is conflict between needs. From the evaluation of existing condition before, this step can be done.
5. Communicate the results to the users in the first step.

2.4 Air Conditioner

Air conditioner is a device to take control of temperature, moisture, cleanliness, air quality, and air circulation in space as required by occupants, process, or product. In the earliest time, air conditioner was used only for heating for those people who lived in places with winter season. (Nuhait, 2008) As the technology keeps developing and the earth temperature is getting warmer, air conditioner can be used for cooling, even dehumidification or humidification in the present time.

2.4.1 Types of Air Conditioner

There are many types of air conditioner because the usage of air conditioner basically depends on the function needed and the volume of the room. The bigger the room, the more the power needed to adjust the room temperature effectively. The capacity of an air conditioner is usually determined by its horse power or commonly known by Paard Kracht (PK). This PK is actually a power unit for compressor of air conditioner. It shows how much power needed for cooling the room. The cooling capacity itself is measured in British Thermal Units (BTUs) per hour. One PK is equal to 9000 BTUs per hour. These types of air conditioner are based on the installation type which has different PK ranges per each.

2.4.1.1 Wall (Split) Air Conditioner

Wall or commonly known as Split Air Conditioner is most frequently used in households or offices. It has two units; indoor unit and outdoor unit. The PK for this air conditioner type ranges from 0.5 to 2.5 PK.

Figure 2.1 Split Air Conditioner (Heat Pump System, 2013)

2.4.1.2 Floor Standing

This type of air conditioner is reflected by its name, where the indoor unit of the air conditioner is installed standing on the floor. In Indonesia, this type of air conditioner is commonly used for cooling a multipurpose hall. PK for this air conditioner type ranges from 2 to 5 PK.

Figure 2.2 Floor Standing Air Conditioner (Made-in-China.com, n.d.)

2.4.1.3 Ceiling

The indoor unit of this air conditioner is installed into the ceiling. This type of air conditioner is usually used for large room with the range of PK between 1.5 to 6. There are also three variations of ceiling air conditioner (AC); the general ceiling AC, ceiling concealed AC, and cassette AC.

Figure 2.3 Ceiling Air Conditioner (Alf-img.com, n.d.)

2.4.1.4 Central

This type of air conditioner looks like the ceiling type at a glance. However, the difference is that this central air conditioner does not have indoor unit. All the cooling processes are conducted in the outdoor unit and the indoor holes only blow the cool air. The PK for this ceiling air conditioner ranges from 20 to 100 PK.

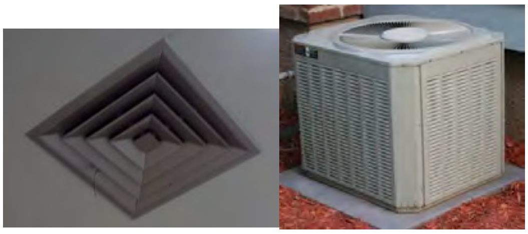

Figure 2.4 The Indoor Hole and Outdoor Unit of Central Air Conditioner (Central Air Conditioners, n.d.)

2.4.1.5 Window

This is an old type of air conditioner and not many people use window air conditioner anymore. It only has one unit and is installed like a window with range of PK between 0.5 to 2.

Figure 2.5 Window Air Conditioner (Rajatrefrigeration.com, n.d.)

2.4.1.6 Portable

This portable air conditioner is practical, it can be moved and carried because all the components unite in one unit. The size of this air conditioner is also small which affect its range of PK is only between 0.5 to 1.

Figure 2.6 Portable Air Conditioner (Lowes.com, n.d.)

2.4.2 Components of Air Conditioner

Air conditioner has a lot of components which are usually divided into indoor and outdoor unit.

2.4.2.1 Evaporator

Evaporator is the component that absorbs the heat from surrounding air in the room. In the evaporator coil, there is a substance in liquid form called refrigerant. If this refrigerant is evaporating or boiling, the refrigerant will change into cool gas. Then, the cool refrigernat gas makes the evaporator cold, which turn the warm air into cool air. This cool air is delivered back to the room.

Figure 2.7 Evaporator (Klinikac.com, 2013)

2.4.2.2 Air Filter

Basically, this component has the function as its name, to filter any dust and dirt from the air that is absorbed from the room before it enters the evaporator. If this air filter is unclean, it will affect to the performance of the air conditioner, which usually causes that the cool air is not optimally produced.

Figure 2.8 Air Filter (Klinikac.com, 2013)

2.4.2.3 Thermostat

Thermostat is a small component which has function to measure the room temperature and then deliver the information to compressor. This component is important because the purpose of the air conditioner is to make the room has the same temperature as displayed in the sensor which was controlled by the user

Figure 2.9 Thermostat (Alibaba.com, n.d.)

2.4.2.4 Sensor

Sensor is the component that receive information from the remote controller and deliver the information to another components. The information can be about the temperature, the function, or the feature that is set by the user.

Figure 2.10 Sensor (Dutaserviceac.com, 2015)

2.4.2.5 Compressor

Compressor is the most critical componen in an air conditioner. Once it is broken, it is better to buy a new air conditioner rather than to buy a new compressor. This compressor may also become disorder because of the failure of some other components. This component has function to compress the gaseous refrigerant into high-pressured gas.

Figure 2.11 Compressor (Kompresor AC, 2014)

2.4.2.6 Condensor

Condensor has similar structure with evaporator, but it is usually put in the outdoor unit since it releases heat. This component receives hot compressed gas from compressor then change the gas into liquid form. This transformation requires heat energy which will be pumped to outdoor.

Figure 2.12 Condensor ((Klinikac.com, 2013)

2.4.2.7 Capasitor

This component is the starter component for compressor to operate. If this component fails, the compressor cannot operate. The capacity of capasitor follows the capacity of the compressor.

Figure 2.13 Capasitor (Klinikac.com, 2013)

2.4.2.8 Overload

Overload is a small component that keeps electricty current flowing to the compressor. If the compressor overworks, it will lead the temperature of compressor increasing. If compressor becomes too hot until some point, overload will cut the electricity flow to force the compressor shut down.

Figure 2.14 Overload (Klinikac.com, 2013)

2.4.2.9 Indoor and Outdoor Fan

Indoor and outdoor fan has the same function, which is to blow and circulate the air. Indoor fan circulates the cool air from evaporator to the room, while outdoor fan circulates the hot air from condensor to the outdoor environment.

Figure 2.15 Indoor and Outdoor Fan (Klinikac.com, 2013)

2.4.2.10 Remote Controller

Remote controller has function as an input device for air conditioner. Remote controller is the component which has contact directly to human as users. It controls the air conditioner based on the users' desire and need.

Figure 2.16 Remote Controller (Amazon.in, n.d.)

2.5 Cooling Load

The cooling load is the amount of heat energy to be removed from a building or a room by the HVAC (Heating, Ventilating, and Air Conditioning) equipment to maintain the indoor temperature. The calculation of the cooling load in this research used the method from Juwana (2008) on his book which titled *Panduan Sistem Bangunan Tinggi*.

2.5.1 Building Sensible Load

Sensible heat is the type of heat that can be measured by a thermometer and felt by our skin. Building sensible load (BSL) is the sensible heat that is owned by the building itself. The heat is kept in the wall and is influenced by the four cardinal directions which are west, north, east, and south. The formulation to calculate BSL is shown below.

$$BSL = Room\ Area\ x\ Heat\ Load$$

(Formulation 2.1)

The heat load is different for each wall. It depends on the material and the direction it faces. In this case, the material of wall is limited into two, the stone and the glass (window).

Table 2.2 Heat Load

	Heat Load (BTU/hr/m^2)
Glass	
North Side	800
South Side	400
East Side	900
West Side	1000
Wall	
North Side	2.15 * ($t_0 - t_1$)
South Side	2.15 * ($t_0 - t_1$)
East Side	2.15 * ($t_0 - t_1$)
West Side	2.16 * ($t_0 - t_1$)

Note: For Indonesia, ($t_0 - t_1$) = 5ºC (Juwana, 2008)

2.5.2 Internal Heat Load

Internal heat load is the heat that comes from the human and the equipment inside the room. In this calculation, the equipment is limited only for the lamp.

- Occupancy

  The occupancy of a room is determined by number of people in the room. In Bappeko, the occupancy means the number of employees in a room.

- People Sensible Load (PSL)

  The sensible heat load of people can be calculated by the formula below.

$$PSL = Occupancy\ x\ 200$$

(Formulation 2.2)

- People Latent Load (PLL)

  The latent heat load of people can be calculated by the formula below.

$$PLL = Occupancy\ x\ 250$$

(Formulation 2.3)

- Lamp Sensible Load (LSL)

  The sensible heat load of lamp can be calculated by the formula below.

$$LSL = (\sum watt)(1.25)\ x\ (3.4)$$

(Formulation 2.4)

2.5.3 Ventilation and Infiltration Load

- Infiltration Load (CFM_1)

  The formulation of infiltration load is shown below.

$$CFM_1 = \frac{l\ x\ w\ x\ h\ x\ ACR\ x\ (35.31)}{60}$$

(Formulation 2.5)

- Ventilation Load (CFM_2)

  The formulation of ventilation load is shown below.

$$CFM_2 = [(t_0 - t_1)\ x\ 1.08 + (RH_0 - RH_1)\ x\ 0.67]$$

(Formulation 2.6)

($t_0 - t_1$) for Indonesia is decided to be 5ºC. RH_0 is the outdoor humidity and RH_1 is the indoor humidity.

Cooling Load (CL)

The cooling load of a room can be calculated by the total of all three heat loads which is shown in the detail formulation below. All units are in BTU/hr.

$$CL = BSL + PSL + PLL + LSL + CFM_1 + CFM_2$$

(Formulation 2.7)

2.6 Survey and Interview

Survey is any activity that collects information in an organized and methodical way about characteristics of interest from some or all units of a population using well-defined concepts, methods and procedures, and compiles such information into a useful summary form (Fellegi, 2013). The survey is conducted in several phases. The first is the planning phase, which is followed by the design and development phase, and then the implementation phase. Then, the entire survey process is reviewed and evaluated. Survey is not only a simple procedure of asking questions and then compiling the answers to produce statistics, but it also needs to be carried out step by step. The steps of conduction a survey are:

1. Defining the objectives
2. Selecting a survey frame
3. Determining the sample design
4. Designing the questionnaire
5. Collecting and processing the data
6. Analysing and deploying the data
7. Documenting the survey

Interview is a data collection method of asking quantitative or qualitative questions orally of key participants (CDC, 2009). Quantitative questions have specific answers to choose among that can be categorized and numerically analyzed, whereas qualitative questions are open-ended, which is the response is delivered in the respondent’s own words. In order to conduct successful interviews, a planning should be conducted first. There are some things listed below that need to be planned before interviewing.

1. Determine the focus
2. Develop an interview guide or questionnaire
3. Select the number and type of people to be interviewed
4. Train the interviewers
5. Ensure the confidentiality of respondents
6. Pilot test the interview guide or questionnaire

2.7 Summary of Previous Researches

This subchapter shows the summary of some previous researches that are related and supported this final project. The summary is presented in the table below.

Table 2.3 Summary of Previous Research

No.	Research Title	Methodology	The Relation to Final Project
1	Design of Change Management among Surabaya Society towards Green Building Using Change Acceleration Process Model (Angga Ari Prasetio, Industrial Engineering Department, ITS, 2013)	Data collection, designing the chance management using Change Acceleration Process (CAP) model, planning the concept of Green Building Awareness Award, Instruments construction	The instruments that were created in this research become the reference in defining the green building aspect for air conditioners.
2	Design Improvement for Green Building Aspect in Bappeko Building Surabaya with House of Quality	Data collection, designing green building framework, evaluation of Green Building Self	The instruments in this research are more detailed and already applied to a city government unit

No.	Research Title	Methodology	The Relation to Final Project
	(Herdian Rachmat Praditya, Industrial Engineering Department, ITS, 2014)	Assessment Instrument (GBSAI) on Bappeko building, design the recommendation of green building aspect	which can be reference for this final project in data collection and data analysis.
3	Conservation of Electrical Energy on Buildings of PT. Sumber Alfaria Trijaya, Tbk. (M. Rafiuddin, Electrical Engineering, Hasanuddin University, 2014)	Energy audit, energy management, energy consumption intensity (ECI)	The research became the reference in this final project because it also calculated the ECI and explained more about energy saving.
4	Saving the Use of Electrical Energy on Aceh Finance Department Office Buildings (Fajar Faris, Electric Power Engineering, Syiah Kuala University, 2014)	Cooling Load, Energy Saving	It had the similar theme of research topic. It also calculated the cooling load of buildings which became the reference in doing this final project.

CHAPTER III
RESEARCH METHODOLOGY

This chapter shows the flowchart of the research methodology that is used for this final project along with the explanation of every steps in the flowchart.

3.1 Flowchart of Research Methodology

In conducting the research for this final project, there are several steps to be finished which is illustrated in the flowchart below.

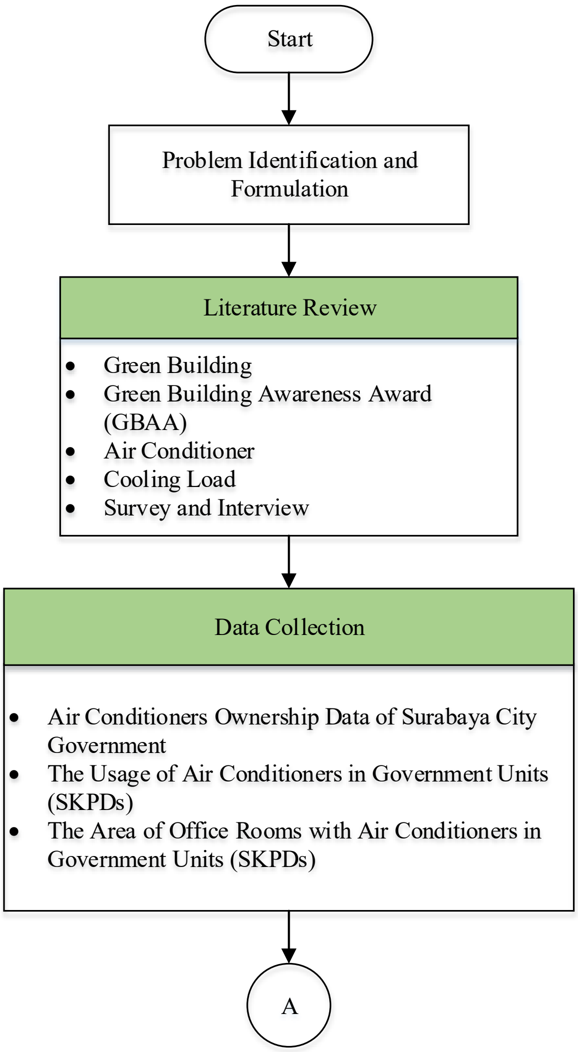

Figure 3.1 Flowchart of Research Methodology

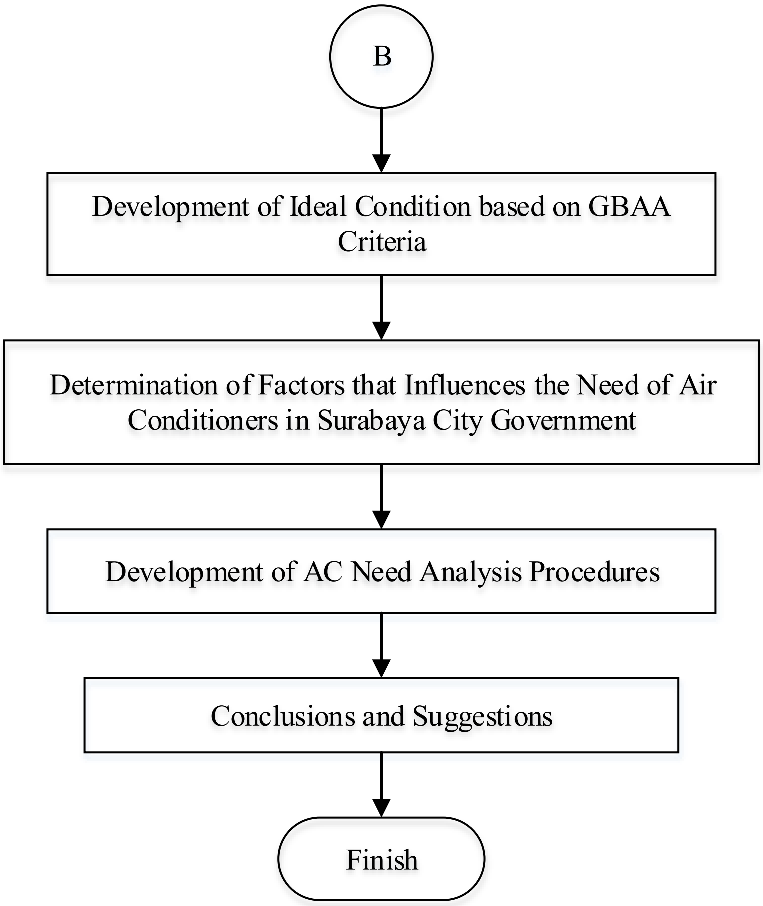

Figure 3.1 Flowchart of Research Methodology (Continued)

3.2 Flowchart Explanation

Based on the flowchart of research methodology on previous sub-chapter, here is the explanation for each steps.

3.2.1 Problem Identification and Formulation

The first step of this research is identifying the problem by gaining information from the Procurement Unit of Surabaya City Government and several government units or Satuan Kerja Perangkat Daerah (SKPD). As been explained previously, Surabaya City Government already started trying to spread Green Building concept to the city by holding Green Building Awareness Award in 2014.

However, the further actions have not been taken after the awarding event was finished. The green building concept is not really applied either in

Surabaya City Government. Focusing on the air conditioners usage, Procurement Unit, as the unit which is responsible for the procurement of government assets, do not have any standards for SKPDs to maintain their air conditioners and to propose for the next purchase according to Green Building concept. Based on the preliminary survey to three SKPDs, which were BAPPEKO, Bagian Bina Program and DPUCKTR, there was no guidance of how they determine the need of new air conditioners. The users of the air conditioners, which are the employees, also do not have standard procedures to optimally use the air conditioner. Thus, it means that the usage of air conditioners does not consider about the green building principle. With the objective of Surabaya to be a green eco-city, the need analysis of air conditioners need to be developed and improved based on the green building principle which is shaped in GBAA criteria.

3.2.2 Data Collection

The next step is to collect data related to air conditioners usage in Surabaya City Government. The data that is needed in the beginning is the database of air conditioners ownership per SKPD. This data can be gained from Procurement Unit. It is already saved in the Surabaya City Government information system which includes all assets that government have. This information system is called SIMBADA (Sistem Informasi Manajemen Barang Daerah). However, the data from SIMBADA has to be verified with the real existing condition since Procurement Unit has confirmed that SIMBADA is not really accurate per SKPD. The verification of data is done by doing the survey directly to SKPD, matching the database from SIMBADA with the actual condition.

After the real data of air conditioners ownership is obtained, the interview is conducted to get the information and data about how the air conditioners are used and maintained. It can be about what temperature those air conditioners work on and what kind of actions taken if the air conditioners are out of order. The data of routine maintenance is necessary if it is possible. Another data that has to be obtained are the electricity usage in the SKPD, especially the electricity usage on air conditioners, and the area of office rooms where the air conditioners located. The electricity usage per SKPD is needed because electricity efficiency becomes one of aspects in GBAA criteria. The area of office rooms is also needed because it becomes the basic information to calculate the capacity need of air conditioners. These data are obtained by doing the interview and survey and looking through the historical information.

3.2.3 Evaluation Analysis of Existing Condition

In this step, the existing data that have been collected are processed so that the existing condition can be evaluated. The first thing to do is to calculate the cooling load for each room in Bappeko. The cooling load calculation considers the volume of the room, the occupancy of the room, and the lighting of the room. It is needed to know whether the cooling need in every room is covered by the current air conditioners. Then, this usage of air conditioners will relate into the energy consumption which will lead into the energy efficiency. Energy efficiency is one of the common and important criteria of GBAA. Therefore, the energy consumption of existing air conditioners is also evaluated whether it is efficient or not. The result of this evaluation can be the input for the next step.

3.2.4 Development of Ideal Condition based on GBAA Criteria

From the evaluation of existing condition in the previous step, the weaknesses of the existing condition will be known. This lack in the existing condition will be reference in developing the ideal condition which still considers GBAA criteria. In short, the ideal condition will be the opposite of the existing condition in good side. This ideal condition can be used as the standard to be compared with the existing condition for improvement.

3.2.5 Determination of Factors that Influence the Need of Air Conditioners in Surabaya City Government

In this step, there will be some interviews with the person in charge of air conditioners asset in the SKPD. The interview will be about the cause, the need, and any conditions that are related in decision to buy new air conditioners. It is also about the lack of the current system which makes trouble between

Procurement Unit and SKPDs in fulfilling air conditioner assets. The result of the interview will be combined with the evaluation of existing condition in order to determine the factors.

3.2.6 Development of Air Conditioners Need Analysis Procedures

After all the evaluation of existing condition has been conducted, the gap between the existing condition with the ideal condition will be shown. The result of this previous step will be the reference in making an air conditioners need analysis procedures. These procedures are the output of this research that will be proposed to the Surabaya City Government in order to improve the management of air conditioners, specifically with the green building principles. The methodology will be focused on how to determine the need of new air conditioners but it considers the green building principle.

3.2.7 Conclusions and Suggestions

This is the last step which means all the data has been processed and analyzed. The conclusion can be taken as the result of the analysis to answer the defined objectives of the research. Then, the recommendation is made to be offered for Surabaya City Government and also for the development of the next research.

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CHAPTER IV
EVALUATION OF EXISTING CONDITION

This chapter elaborates the existing condition related to air conditioners usage and management in Bappeko. It also includes some data and the evaluation of the existing condition.

4.1 The Existing Condition of AC Usage Management

All assets owned by Surabaya city government are recorded in SIMBADA. SIMBADA is an information system for the government assets management. This system is created to ease and quicken assets management processes, reduce data error, and reduce manual processes. In SIMBADA, all data of air conditioners ownership per SKPD are archived. A preliminary survey was conducted to verify whether the data in SIMBADA was matching with the real condition in government SKPD. This survey was conducted at three SKPDs, there are Bappeko, DPUCKTR, and Bina Program. Those SKPDs were chosen with the recommendation of Procurement Unit in order to have a general description about the actual existing condition of SIMBADA.

However, based on that survey, the air conditioners data in SIMBADA was found not accordance with the real condition. In the beginning, the SIMBADA itself was not really completely filled, some brands and types were missing which made the survey was hard to be done. It can be seen in the Figure 4.1 below.

No. of Register	Asset Code	Asset Name	Brand	Type	Quanti
8708213-1	1.3.2.15.04	AC. Split 2 PK	AUX	ASW-184/EA	1
147274	1.3.2.15.04	A.C. SPLIT	PANASONIC	-	1
147274	1.3.2.15.04	A.C. SPLIT	PANASONIC	-	1
147274.0001	1.3.2.15.04	A.C. SPLIT	PANASONIC	SPLIT	1
147274	1.3.2.15.04	A.C. SPLIT	PANASONIC	-	1

Figure 4.1 The Sample of SIMBADA Record

There was no real data about the allocation of air conditioners per room. From SIMBADA, most of the type of air conditioners are unknown and it is also not known which air conditioners in which room. Even though every SKPDs put KIR (Card of Room Inventory) in each room in their buildings, but some of them were not updated and less detailed than SIMBADA.

The survey also resulted that not all air conditioners listed in SIMBADA were available and still in use. Some air conditioners were out of order and were not used anymore, but they were still on the list. On the other hand, there were some new air conditioners purchase, but they were not recorded. The air conditioners could have more or less number than what was listed in SIMBADA.

There was also no further procedure how to determine the needs of new air conditioners and how to do the proper operation and maintenance. The Procurement Unit does not have guidance for air conditioners allocation either. If any SKPD requests for new air conditioners, Procurement Unit cannot verify whether that SKPD really need new ones or not.

4.2 The Existing Condition of AC Usage in Bappeko

The usage of air conditioners in Bappeko is not monitored well because there is no regulation about it. The users of the air conditioners, – in this case, the users are employees in Bappeko –, are also not acknowledged to use the air conditioners optimally. Daily, the air conditioners are turned on the whole day during the working hours. The users operate air conditioner on the temperature they are desired, whereas there is actually a regulation that the air conditioner should be turned on between 24-27 ºC due to the energy saving. Some AC remote controllers also have broken display monitor, so that the temperature itself cannot even be identified.

Related to the usage of air conditioner, the staff of the asset management staff in Bappeko, air conditioners have routine cleaning and maintenance once per 4 months. However, it is never recorded when the exact date of cleaning and maintenance was along with the latest condition checked. This data is quite important for decision making in the future. If the air conditioner is out of order, this data will be helpful to determine whether that air conditioner should be replaced or only needs to be repaired. This kind of decision making is also related to the age or the lifetime of air conditioners which is not monitored either. There are some air conditioners that are already more than 10 years, but it is not recorded whether it is still in good condition or ever given special maintenance or so on.

In order to explore deeper about the existing condition, some evaluations are conducted. These are useful to know whether the existing air conditioners are technically sufficient for the current cooling need and are already accordance with the green building criteria. This green building evaluation of the air conditioner is only focused on the energy consumption. Therefore, the energy consumption of the air conditioners will be analyzed.

Some data have been collected to conduct that evaluation. The data consist of the room length, the room width, number of people in the room, and number of operating lamps. These are considered as the basic data to calculate the cooling load as the parameter of evaluating existing condition. The layout of each floor is also created along with the information of air conditioners in each room.

4.2.1 The Existing Data of First Floor

The existing data of the first floor, which contains the room size, number of people in the room, and number of operating lamps, are summarized in the table below.

Table 4.1 Existing Data of First Floor

No.	Room Name	Room Length (m)	Room Width (m)	No. of People	No. of Operating Lamps
1	Head of Environment and Spatial Sub Department	3,94	2,9	1	1
2	Head of Transportation and Drainage Sub Department	3,94	2,9	1	1
3	Head of Public Welfare Sub Department	3,94	2,9	1	1
4	Head of Government Apparatus and Citizenship Sub Department	3,94	2,9	1	1
5	Head of Physical and Infrastructure Department	3,63	5,59	1	5
6	Physical and Infrastructure Staff	19,25	11,7	61	30
7	Singosari	7,85	5,84	20	5

Table 4.2 Existing Data of First Floor (Continued)

No.	Room Name	Room Length (m)	Room Width (m)	No. of People	No. of Operating Lamps
8	Head of Public Welfare and Government Apparatus Department	3,92	5,84	1	5

As it can be seen in table 4.1, the first floor consists of rooms for employees under the Public Welfare and Government Apparatus Department and Physical and Infrastructure Department. The first floor has a huge room for the staffs and every heads of the departments and sub departments have their own rooms. The layout of the first floor can be seen on the figure 4.1 below.

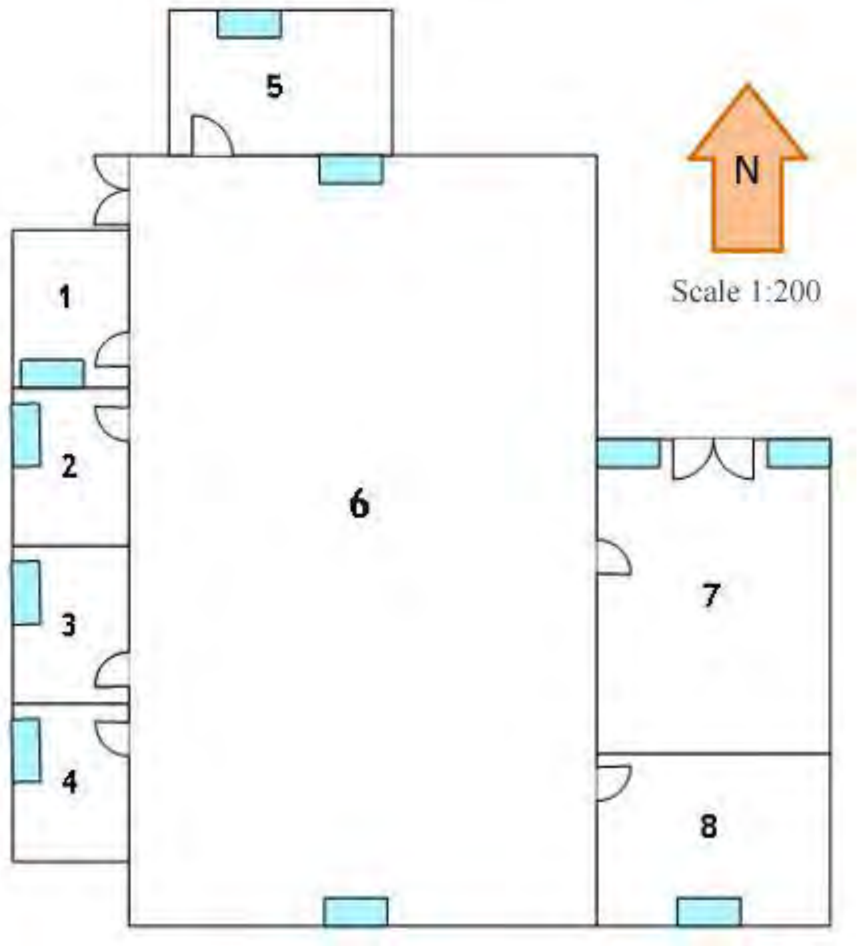

Figure 4.2 Room Layout of First Floor

The description of the room names for each number is listed in the table below.

Table 4.3 First Floor Layout Description

No.	Room Name	Merk and Type of AC	Input Power (Watt)
1	Head of Environment and Spatial Sub Department	LG S09LS-1	795
2	Head of Transportation and Drainage Sub Department	Panasonic CS-PC9MKH	865
3	Head of Public Welfare Sub Department	Panasonic CS-PC9MKH	865
4	Head of Government Apparatus and Citizenship Sub Department	Panasonic CS-PC9MKH	865
5	Head of Physical and Infrastructure Department	Panasonic CS-PC18GKP	1920
6	Physical and Public Welfare Staff	LG LP-C508TAO	4800
		LG LP-C508TAO	4800
7	Singosari	Panasonic CS-PC18PKP	1920
		Panasonic CS-PC18PKP	1920
8	Head of Public Welfare and Government Apparatus Department	Panasonic CS-C12HKH	1150

4.2.2 The Existing Data of Second Floor

The existing data of the second floor, which contains the room size, number of people in the room, and number of operating lamps, are summarized in the table below.

Table 4.4 Existing Data of Second Floor

No.	Room Name	Room Length (m)	Room Width (m)	No. of People	No. of Operating Lamps
1	Head of Agriculture, Marine, and Tourism Sub Department	3,05	2,70	1	1
2	Head of Business Development Sub Department	3,54	3,20	1	1
3	Head of General and Staffing Sub Section	4,00	3,20	1	1
4	Head of Finance Sub Section	3,91	3,20	1	1
5	Head of Work Plan Arrangement Sub Section	3,75	3,20	1	1
6	Secretariat Staff	28,91	5,62	50	16
7	Head of Economy Department	3,50	6,00	1	1
8	Borobudur	9,70	6,00	20	5

Table 4.5 Existing Data of Second Floor (Continued)

No.	Room Name	Room Length (m)	Room Width (m)	No. of People	No. of Operating Lamps
9	Waiting Room	4,70	6,00	1	2
10	Secretary	3,31	6,00	1	2
11	Head of Bappeko	9,37	5,87	1	5

The second floor is quite similar with the first floor. It has a big long room for the staffs of Secretariat and the staffs under the Economy Department. The head of Bappeko also has his room in this floor. This floor is focused for the employees who work under the Secretary and under the Economy Department. The layout of the second floor can be seen on the figure below.

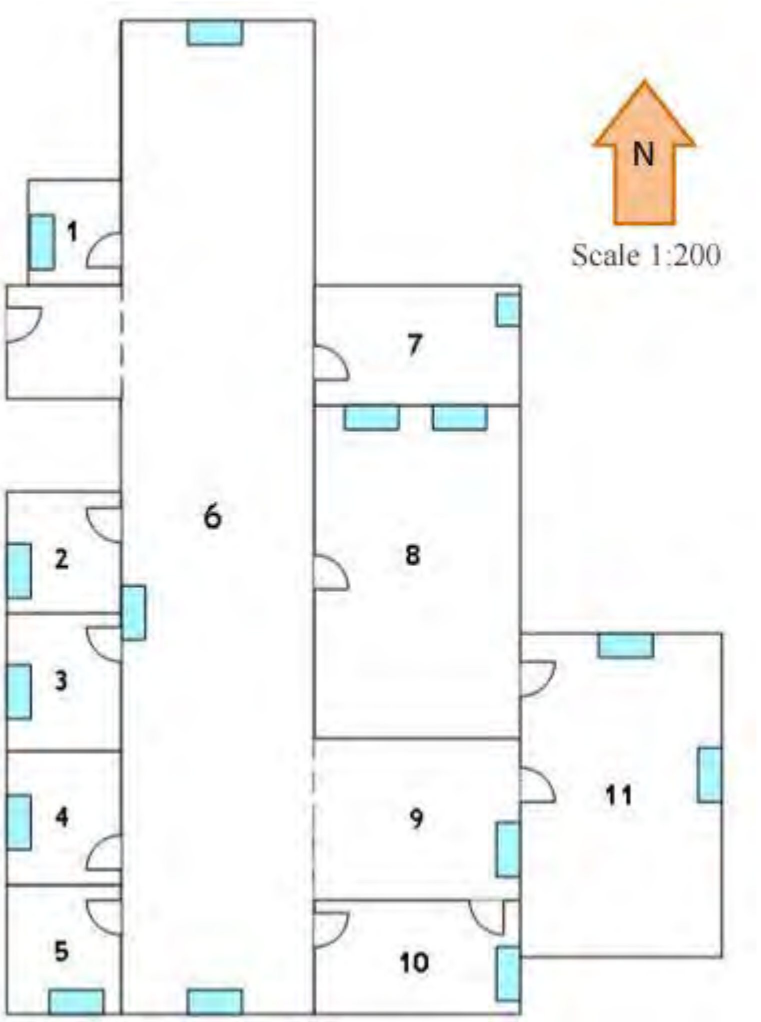

Figure 4.3 Room Layout of Second Floor

The description of the room names for each number is listed in the Table 4.4 below.

Table 4.6 Second Floor Layout Description

No.	Room Name	Merk and Type of AC	Input Power (Watt)
1	Head of Agriculture, Marine, and Tourism Sub Department	LG S09LS-1	795
2	Head of Business Development Sub Department	Panasonic CS-C18JKP	590
3	Head of General and Staffing Sub Section	Panasonic CS-PC7PKJ	595
4	Head of Finance Sub Section	Mitsubishi SRK09CRP-S3	925
5	Head of Work Plan Arrangement Sub Section	Mitsubishi SRK09CRP-S3	925
6	Secretariat and Economy Staff	Panasonic CS-C18JKP	590
		Panasonic CS-C18NKP	1750
		Panasonic CS-C18NKP	1750
7	Head of Economy Department	Mitsubishi SRK09CRP-S3	925
8	Borobudur	Panasonic CS-PC18PKP	1920
		Panasonic CS-PC18PKP	1920
9	Waiting Room	Panasonic CS-C18JKP	590
10	Secretary	LG S18LG-2	1800
12	Head of Bappeko	Panasonic CS-PC18GKP	1920
		Panasonic CS-PC18GKP	1920

4.2.3 The Existing Data of Third Floor

The existing data of the third floor, which contains the room size, number of people in the room, and number of operating lamps, are summarized in the table below.

Table 4.7 Existing Data of Third Floor

No.	Room Name	Room Length (m)	Room Width (m)	No. of People	No. of Operating Lamps
1	Transit	6,10	5,65	5	5
2	Suramap	3,08	6,66	7	3
3	Penataran	3,72	4,99	7	3
4	Clinic 1	6,10	4,99	3	2
5	Clinic 2	2,32/	6,85	4	2
6	Prambanan	9,16	6,85	20	6
7	Scheme (Pola)	17,50	14,70	250	17

The third floor mostly consists of rooms for outsourcings and meeting rooms. There is a huge room in the middle of the third floor which has the function as a hall. There is also a room called Transit Room that has function as the waiting room for important guests. The layout of the third floor can be seen on the figure below.

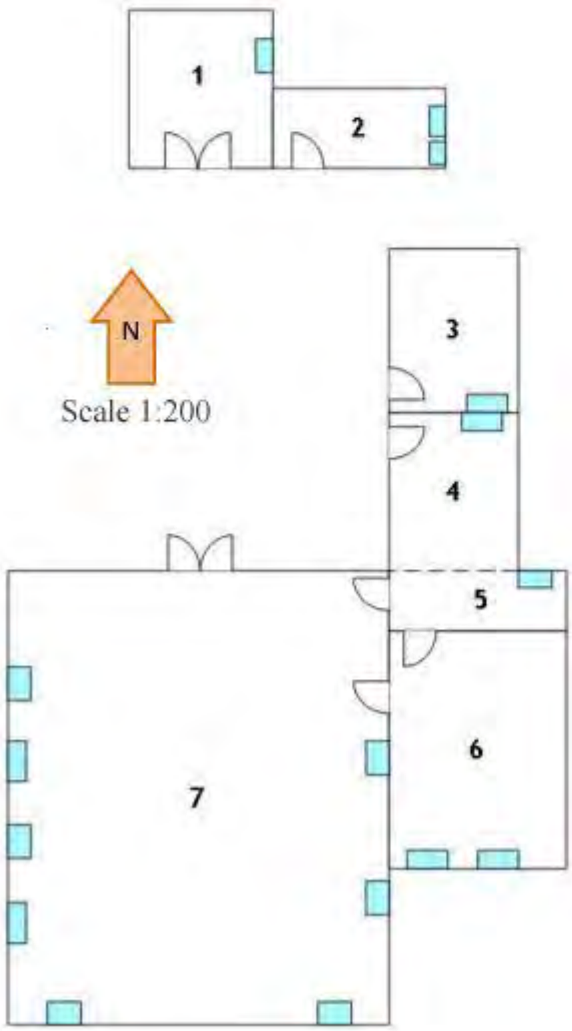

Figure 4.4 Room Layout of Second Floor

The description of the room names for each number is listed in the table below.

Table 4.8 Third Floor Layout Description

No.	Room Name	Merk and Type of AC	Input Power (Watt)
1	Transit	LG S18LG-2	1800
2	Suramap	Mitsubishi SRK09CRP-S3	925

Table 4.6 Third Floor Layout Description (Continued)

No.	Room Name	Merk and Type of AC	Input Power (Watt)
		Panasonic CS-C12HKH	1150
3	Penataran	AUX ASW-184/EA	2080
4	Clinic 1	Panasonic CS-PC18PKP	1920
5	Clinic 2	Panasonic CS-PC9MKH	865
6	Prambanan	Panasonic CS-PC18GKP	1920
		Panasonic CS-C12HKH	1150
7	Scheme (Pola)	LG LP-C508TAO	4800
		LG LP-C508TAO	4800
		LG LP-C508TAO	4800
		LG LP-C508TAO	4800
		Panasonic CS-PC18GKP	1920
		Panasonic CS-PC18GKP	1920
		Panasonic CS-PC18GKP	1920
		Panasonic CS-PC18GKP	1920

All the layouts of the rooms together with the air conditioners inside are needed in order to understand the size of the room. The wind direction is also important for the next step and these layouts make it easy to determine the wind direction for each room.

4.3 The Calculation of Existing Cooling Load

The calculation of cooling load followed the calculation method in (Juwana, 2008) with the title of *Panduan Sistem Bangunan Tinggi*. There are some calculation steps to be followed in order to gain the existing cooling load. The equations of the formula have been listed in sub-chapter 2.4.

4.3.1 Cooling Load Calculation of First Floor

These are the results of the cooling load calculation based on the formulations in sub-chapter 2.4.

- Building Sensible Load (BSL)

  Building Sensible Load (BSL) is calculated by using the (Formulation 2.1). The calculation result can be seen in the Table 4.7.

Table 4.9 Building Sensible Load (BSL) of First Floor

No.	Room Name	North Side	South Side	East Side	West Side	BSL
1	Head of Environment and Spatial Sub Department	89.78	89.78	121.98	122.55	424.10
2	Head of Transportation and Drainage Sub Department	89.78	89.78	121.98	1270.02	1571.57
3	Head of Public Welfare Sub Department	89.78	89.78	121.98	1270.02	1571.57
4	Head of Government Apparatus and Citizenship Sub Department	89.78	89.78	121.98	1270.02	1571.57
5	Head of Physical and Infrastructure Department	173.07	173.07	4434.14	112.91	4893.18
6	Physical and Public Welfare Staff	362.23	362.23	595.98	598.75	1919.20
7	Singosari	6818.08	180.81	243.04	244.17	7486.09
8	Head of Public Welfare and Government Apparatus Department	180.81	180.81	1832.65	121.93	2316.20

- People Sensible Load (PSL) and People Latent Load (PLL)

  People Sensible Load (PSL) and People Latent Load (PLL) are calculated by using the (Formulation 2.2 and 2.3). The calculation result can be seen in the Table 4.8.

Table 4.10 People Sensible Load (PSL) and People Latent Load (PLL) of First Floor

No.	Room Name	Occupancy	PSL	PLL
1	Head of Environment and Spatial Sub Department	1	200	250
2	Head of Transportation and Drainage Sub Department	1	200	250
3	Head of Public Welfare Sub Department	1	200	250

Table 4.8 People Sensible Load (PSL) and People Latent Load (PLL) of First Floor (Continued)

No.	Room Name	Occupancy	PSL	PLL
4	Head of Government Apparatus and Citizenship Sub Department	1	200	250
5	Head of Physical and Infrastructure Department	1	200	250
6	Physical and Infrastructure Staff	61	12200	15250
7	Singosari	20	4000	5000
8	Head of Public Welfare and Government Apparatus Department	1	200	250

- Lamp Sensible Load (LSL)

  Lamp Sensible Load (LSL) is calculated by using the (Formulation 2.4). The calculation result can be seen in the Table 4.9.

Table 4.11 Lamp Sensible Load (LSL) of First Floor

No.	Room Name	No. of Operating Lamps	Total Wattage	LSL
1	Head of Environment and Spatial Sub Department	2	20	68
2	Head of Transportation and Drainage Sub Department	2	20	68
3	Head of Public Welfare Sub Department	1	10	34
4	Head of Government Apparatus and Citizenship Sub Department	1	10	34
5	Head of Physical and Infrastructure Department	6	60	204
6	Physical and Infrastructure Staff	38	380	1292
7	Singosari	8	80	272
8	Head of Public Welfare and Government Apparatus Department	4	40	136

- Infiltration Load (CFM_1) and Ventilation Load (CFM_2)

  Infiltration Load (CFM_1) and Ventilation Load (CFM_2) are calculated by using the (Formulation 2.5 and 2.6). The calculation result can be seen in the Table 4.10.

Table 4.12 Infiltration Load (CFM1) and Ventilation Load (CFM2) of First Floor

No.	Room Name	CFM1	CFM2
1	Head of Environment and Spatial Sub Department	58.10	32.2
2	Head of Transportation and Drainage Sub Department	58.10	32.2
3	Head of Public Welfare Sub Department	58.10	32.2
4	Head of Government Apparatus and Citizenship Sub Department	58.10	32.2
5	Head of Physical and Infrastructure Department	103.18	32.2
6	Physical and Infrastructure Staff	1145.19	32.2
7	Singosari	233.10	32.2
8	Head of Public Welfare and Government Apparatus Department	116.40	32.2

- Existing Cooling Load (CL)

  The existing Cooling Load (CL) is calculated by using the (Formulation 2.7). The calculation result can be seen in the Table 4.11.

Table 4.13 The existing Cooling Load (CL) of First Floor

No.	Room Name	Cooling Load (BTU/h)
1	Head of Environment and Spatial Sub Department	1032.40
2	Head of Transportation and Drainage Sub Department	2179.87
3	Head of Public Welfare Sub Department	2145.87
4	Head of Government Apparatus and Citizenship Sub Department	2145.87
5	Head of Physical and Infrastructure Department	5682.56
6	Physical and Infrastructure Staff	31838.58
7	Singosari	17023.39
8	Head of Public Welfare and Government Apparatus Department	3050.80

4.3.2 Cooling Load Calculation of Second Floor

These are the results of the cooling load calculation based on the formulations in sub-chapter 2.4.

- Building Sensible Load (BSL)

  Building Sensible Load (BSL) is calculated by using the (Formulation 2.1). The calculation result can be seen in the Table 4.12.

Table 4.14 Building Sensible Load (BSL) of Second Floor

No.	Room Name	North Side	South Side	East Side	West Side	BSL
1	Head of Agriculture, Marine, and Tourism Sub Department	83.59	83.59	94.43	94.87	356.48
2	Head of Business Development Sub Department	99.07	99.07	109.60	110.11	417.85
3	Head of General and Staffing Sub Section	99.07	99.07	123.84	124.42	446.40
4	Head of Finance Sub Section	99.07	99.07	121.05	121.62	440.81
5	Head of Work Plan Arrangement Sub Section	99.07	99.07	116.10	116.64	430.88
6	Secretariat and Economy Staff	174.00	174.00	895.05	899.22	2142.26
7	Head of Economy Department	185.76	185.76	108.36	108.86	588.74
8	Borobudur	185.76	185.76	300.31	301.71	973.54
9	Waiting Room	185.76	185.76	145.51	146.19	663.22
10	Secretary	185.76	185.76	102.48	102.95	576.95
12	Head of Bappeko	181.74	181.74	290.10	291.44	945.01

- People Sensible Load (PSL) and People Latent Load (PLL)

  People Sensible Load (PSL) and People Latent Load (PLL) are calculated by using the (Formulation 2.2 and 2.3). The calculation result can be seen in the Table 4.13.

Table 4.15 People Sensible Load (PSL) and People Latent Load (PLL) of Second Floor

No.	Room Name	Occupancy	PSL	PLL
1	Head of Agriculture, Marine, and Tourism Sub Department	1	200	250
2	Head of Business Development Sub Department	1	200	250

Table 4.16 People Sensible Load (PSL) and People Latent Load (PLL) of Second Floor (Continued)

No.	Room Name	Occupancy	PSL	PLL
3	Head of General and Staffing Sub Section	1	200	250
4	Head of Finance Sub Section	1	200	250
5	Head of Work Plan Arrangement Sub Section	1	200	250
6	Secretariat and Economy Staff	50	10000	12500
7	Head of Economy Department	1	200	250
8	Borobudur	20	4000	5000
9	Waiting Room	1	200	250
10	Secretary	1	200	250
12	Head of Bappeko	1	200	250

- Lamp Sensible Load (LSL)

  Lamp Sensible Load (LSL) is calculated by using the (Formulation 2.4). The calculation result can be seen in the Table 4.14.

Table 4.17 Lamp Sensible Load (LSL) of Second Floor

No.	Room Name	No. of Operating Lamps	Total Watt	LSL
1	Head of Agriculture, Marine, and Tourism Sub Department	1	10	42.5
2	Head of Business Development Sub Department	2	20	85
3	Head of General and Staffing Sub Section	1	10	42.5
4	Head of Finance Sub Section	3	30	127.5
5	Head of Work Plan Arrangement Sub Section	2	20	85
6	Secretariat and Economy Staff	25	250	1062.5
7	Head of Economy Department	7	70	297.5
8	Borobudur	16	160	680
9	Waiting Room	5	50	212.5
10	Secretary	11	110	467.5
12	Head of Bappeko	28	280	1190

- Infiltration Load (CFM_1) and Ventilation Load (CFM_2)

  Infiltration Load (CFM_1) and Ventilation Load (CFM_2) are calculated by using the (Formulation 2.5 and 2.6). The calculation result can be seen in the Table 4.15.

Table 4.18 Infiltration Load (CFM1) and Ventilation Load (CFM2) of Second Floor

No.	Room Name	CFM1	CFM2
1	Head of Agriculture, Marine, and Tourism Sub Department	41.87	32.2
2	Head of Business Development Sub Department	57.60	32.2
3	Head of General and Staffing Sub Section	65.08	32.2
4	Head of Finance Sub Section	63.62	32.2
5	Head of Work Plan Arrangement Sub Section	61.02	32.2
6	Secretariat and Economy Staff	826.12	32.2
7	Head of Economy Department	106.78	32.2
8	Borobudur	295.93	32.2
9	Waiting Room	143.39	32.2
10	Secretary	100.98	32.2
12	Head of Bappeko	279.66	32.2

- Existing Cooling Load (CL)

  The existing Cooling Load (CL) is calculated by using the (Formulation 2.7). The calculation result can be seen in the Table 4.16.

Table 4.19 Existing Cooling Load of Second Floor

No.	Room Name	Cooling Load (BTU/h)
1	Head of Agriculture, Marine, and Tourism Sub Department	923.05
2	Head of Business Development Sub Department	1042.65
3	Head of General and Staffing Sub Section	1036.18
4	Head of Finance Sub Section	1114.13
5	Head of Work Plan Arrangement Sub Section	1059.10
6	Secretariat and Economy Staff	26563.08
7	Head of Economy Department	1475.22
8	Borobudur	10981.67

Table 4.16 Existing Cooling Load of Second Floor (Continued)

No.	Room Name	Cooling Load (BTU/h)
9	Waiting Room	1501.31
10	Secretary	1627.63
12	Head of Bappeko	2896.87

4.3.3 Cooling Load Calculation of Third Floor

These are the results of the cooling load calculation based on the equations in sub-chapter 2.4.

- Building Sensible Load (BSL)

  Building Sensible Load (BSL) is calculated by using the (Formulation 2.1). The calculation result can be seen in the Table 4.17.

Table 4.20 Building Sensible Load (BSL) of Third Floor

No.	Room Name	North Side	South Side	East Side	West Side	BSL
1	Transit	174.92	174.92	188.86	189.73	728.44
2	Suramap	206.19	206.19	95.36	95.80	603.54
3	Penataran	154.49	154.49	115.17	115.71	539.86
4	Clinic 1	154.49	154.49	188.86	189.73	687.57
5	Clinic 2	212.08	212.08	71.83	72.16	568.14
6	Prambanan	212.08	212.08	283.59	284.91	992.66
7	Scheme (Pola)	455.11	455.11	541.80	544.32	1996.34

- People Sensible Load (PSL) and People Latent Load (PLL)

  People Sensible Load (PSL) and People Latent Load (PLL) are calculated by using the (Formulation 2.2 and 2.3). The calculation result can be seen in the Table 4.18.

Table 4.21 People Sensible Load (PSL) and People Latent Load (PLL) of Third Floor

No.	Room Name	Occupancy	PSL	PLL
1	Transit	5	1000	1250
2	Suramap	7	1400	1750
3	Penataran	7	1400	1750
4	Clinic 1	3	600	750
5	Clinic 2	4	800	1000

Table 4.18 People Sensible Load (PSL) and People Latent Load (PLL) of Third Floor (Continued)

No.	Room Name	Occupancy	PSL	PLL
6	Prambanan	20	4000	5000
7	Scheme (Pola)	250	50000	62500

- Lamp Sensible Load (LSL)

  Lamp Sensible Load (LSL) is calculated by using the (Formulation 2.4). The calculation result can be seen in the Table 4.19.

Table 4.22 Lamp Sensible Load (LSL) of Third Floor

No.	Room Name	No. of Operating Lamps	Total Watt	LSL
1	Transit	7	70	297.5
2	Suramap	4	40	170
3	Penataran	2	20	85
4	Clinic 1	2	20	85
5	Clinic 2	3	30	127.5
6	Prambanan	15	150	637.5
7	Scheme (Pola)	35	350	1487.5

- Infiltration Load (CFM_1) and Ventilation Load (CFM_2)

  Infiltration Load (CFM_1) and Ventilation Load (CFM_2) are calculated by using the (Formulation 2.5 and 2.6). The calculation result can be seen in the Table 4.20.

Table 4.23 Infiltration Load (CFM1) and Ventilation Load (CFM2) of Third Floor

No.	Room Name	CFM1	CFM2
1	Transit	175.24	32.2
2	Suramap	104.30	32.2
3	Penataran	94.39	32.2
4	Clinic 1	154.77	32.2
5	Clinic 2	80.81	32.2
6	Prambanan	319.04	32.2
7	Scheme (Pola)	1308.02	32.2

- Existing Cooling Load (CL)

  The existing Cooling Load (CL) is calculated by using the (Formulation 2.7). The calculation result can be seen in the Table 4.21.

Table 4.24 The Existing Cooling Load (CL) of Third Floor

No.	Room Name	Cooling Load (BTU/h)
1	Transit	3483.38
2	Suramap	4060.04
3	Penataran	3901.44
4	Clinic 1	2309.54
5	Clinic 2	2608.65
6	Prambanan	10981.40
7	Scheme (Pola)	117324.07

4.4 Evaluation of Existing AC Capacity

After the cooling load for all rooms has been calculated, the existing Air Conditioner capacity can be evaluated. For each type of air conditioner, the unit called PK or *Paard Kracht* is known. PK is a power that is needed for cooling the room. One PK is equal to 9000 BTU/h. The PK of air conditioners in a room is summed then the total is converted into BTU/h. After that, the result is compared with the cooling load that has been calculated before.

4.4.1 Comparison of Existing AC Capacity and Calculated Cooling Load

The cooling load that has been calculated is compared with the existing capacity of current air conditioners. If the capacity exceeds the cooling load, it means that the existing air conditioners is over capacity.

- Evaluation of First Floor

  The comparison of existing air conditioner capacity and calculated cooling load for the rooms on the first floor can be seen in the table 4.22 below.

Table 4.25 Comparison of Existing AC Capacity and Calculated Cooling Load of First Floor

No.	Room Name	Merk and Type of AC	PK	Existing AC Capacity (BTU/h)	Cooling Load (BTU/h)	Note
1	Head of Environment and Spatial Sub Department	LG S09LS-1	1	9000	1032.40	Over Capacity
2	Head of Transportation and Drainage Sub Department	Panasonic CS-PC9MKH	1	9000	2179.87	Over Capacity
3	Head of Public Welfare Sub Department	Panasonic CS-PC9MKH	1	9000	2145.87	Over Capacity
4	Head of Government Apparatus and Citizenship Sub Department	Panasonic CS-PC9MKH	1	9000	2145.87	Over Capacity
5	Head of Physical and Infrastructure Department	Panasonic CS-PC18GKP	2	18000	5682.56	Over Capacity
6	Physical and Public Welfare Staff	LG LP-C508TAO	5	90000	31838.58	Over Capacity
		LG LP-C508TAO	5			
7	Singosari	Panasonic CS-PC18PKP	2	36000	17023.39	Over Capacity
		Panasonic CS-PC18PKP	2			
8	Head of Public Welfare and Government Apparatus Department	Panasonic CS-C12HKH	1.5	13500	3050.80	Over Capacity

- Evaluation of Second Floor

  The comparison of existing air conditioner capacity and calculated cooling load for the rooms on the first floor can be seen in the table 4.23 below.

Table 4.26 Comparison of Existing AC Capacity and Calculated Cooling Load of Second Floor

No.	Room Name	Merk and Type of AC	PK	Existing AC Capacity (BTU/h)	Cooling Load (BTU/h)	Note
1	Head of Agriculture, Marine, and Tourism Sub Department	LG S09LS-1	1	9000	914.55	Over Capacity
2	Head of Business Development Sub Department	Panasonic CS-C18JKP	1	9000	1025.65	Over Capacity
3	Head of General and Staffing Sub Section	Panasonic CS-PC7PKJ	0.75	6750	1027.68	Over Capacity
4	Head of Finance Sub Section	Mitsubishi SRK09CRP-S3	1	9000	2236.11	Over Capacity
5	Head of Work Plan Arrangement Sub Section	Mitsubishi SRK09CRP-S3	1	9000	2189.57	Over Capacity
6	Secretariat and Economy Staff	Panasonic CS-C18JKP	1	45000	32737.83	Over Capacity
		Panasonic CS-C18NKP	2			
		Panasonic CS-C18NKP	2			
7	Head of Economy Department	Mitsubishi SRK09CRP-S3	1	9000	1415.72	Over Capacity
8	Borobudur	Panasonic CS-PC18PKP	2	36000	14822.59	Over Capacity
		Panasonic CS-PC18PKP	2			
9	Waiting Room	Panasonic CS-C18JKP	1	9000	1458.81	Over Capacity
10	Secretary	LG S18LG-2	2	18000	1534.13	Over Capacity
12	Head of Bappeko	Panasonic CS-PC18GKP	2	36000	6553.34	Over Capacity
		Panasonic CS-PC18GKP	2			

- Evaluation of Third Floor

  The comparison of existing air conditioner capacity and calculated cooling load for the rooms on the first floor can be seen in the table 4.24 below.

Table 4.27 Comparison of Existing AC Capacity and Calculated Cooling Load of Third Floor

No.	Room Name	Merk and Type of AC	PK	Existing AC Capacity (BTU/h)	Cooling Load (BTU/h)	Note
1	Transit	LG S18LG-2	2	18000	7883.14	Over Capacity
2	Suramap	Mitsubishi SRK09CRP-S3	1	22500	11595.27	Over Capacity
		Panasonic CS-C12HKH	1.5			
3	Penataran	AUX ASW-184/EA	2	18000	3884.44	Over Capacity
4	Clinic 1	Panasonic CS-PC18PKP	2	18000	2292.54	Over Capacity
5	Clinic 2	Panasonic CS-PC9MKH	1	9000	2583.15	Over Capacity
6	Prambanan	Panasonic CS-PC18GKP	2	31500	10853.90	Over Capacity
		Panasonic CS-C12HKH	1.5			
7	Scheme (Pola)	LG LP-C508TAO	5	45000	118174.04	Under Capacity
		LG LP-C508TAO	5			
		LG LP-C508TAO	5			
		LG LP-C508TAO	5			
		Panasonic CS-PC18GKP	2			
		Panasonic CS-PC18GKP	2			
		Panasonic CS-PC18GKP	2			
		Panasonic CS-PC18GKP	2			

4.4.2 *Analysis of Existing AC Capacity*

Cooling load is the amount of heat load in a room or in a building that needs to be cooled. By having air conditioners with suitable cooling capacity, the room will be cooled in the normal speed. The comfort of the users inside the room can also be built. In the calculation, this cooling capacity is influenced by the number of people inside the room, the lamps in the room, and especially the size of the glass window. The higher the number of people who occupy the room, the more lamps in the room, and the wider size of glass window can increase the cooling needed in the room. It means that it needs air conditioner with higher capacity.

In the previous sub-chapter, it can be seen that the air conditioning capacity in most of rooms exceeded the normal cooling load. Looking at the number, for example, the room of environment and spatial sub department head has excessive air conditioning capacity compared with the calculated cooling load..For normal condition, the cooling capacity only needs 1032.40 BTU/h but the room has the capacity of 9000 BTU/h. The difference is quite big then it actually makes the current air conditioner is over capacity. It also occurs to other rooms. Overcapacity in using air conditioner will lead into wasting the energy, because actually the energy that is spent can be lower than that.

However, it also means that the cooling capacity has been fulfilled and the employees inside each room are expected to be comfortable. The room should be cool enough or even it will make the room more chilled. Then, there is no reason to add or purchase new air conditioner because the cooling need has been fulfilled.

4.5 Evaluation of AC Energy Efficiency

Based on Minister Regulation about Energy and Mineral Resources No. 13 Year 2012, there are standards for the Energy Consumption Intensity (ECI) for Government Office Buildings. The ECI shows the standard of how much the energy consumption to be called as efficient. The standard of ECI for Air Conditioner usage in Government Office Buildings is shown in the table below.

Table 4.28 Standard of ECI for Air Conditioner usage in Government Office Buildings

Criteria	AC Energy Consumption (kWh/m^2/year)
Very Efficient	<61.2
Efficient	61.2 – 100.8
Less Efficient	100.8 – 133.2
Not Efficient	>133.2

If the total energy needed for all air conditioners per room is lower than 61.2 kWh/m^2/year, the usage of the air conditioners is categorized as very efficient. More than that number until 100.8 kWh/m^2/year, it is still acceptable since it is efficient. The criteria is less efficient if the energy consumes between 100.8 until 133.2 kWh/m^2/year. If the energy consumption is bigger than 133.2 kWh/m^2/year, it is definitely categorized as not efficient.

4.5.1 Evaluation of AC Energy Efficiency in Bappeko

Every air conditioner has input power which means how much power energy needed to operate an air conditioner. This input power is multiplied by the operating hours in a year, how long the air conditioner is used. Most of the operating hours is the same as the working hours of government employees which is 8 hours per day, with 325 days per year. After that, the resulted number is converted into kWh unit by dividing them with 1000. Then, it is divided again by the area of the room to gain the total energy per kWh/m^2/year. This total energy then is compared with the standard to know whether the energy usage is efficient or not.

- AC Energy Efficiency of First Floor

  The comparison between the total energy of air conditioners on the first floor and the standard of ECI is shown in the table 4.26 below.

Table 4.29 AC Energy Efficiency of First Floor

No.	Room Name	Merk and Type of AC	Input Power (Watt)	Total Energy (kWh/m2/year)	Criteria
1	Head of Environment and Spatial Sub Department	LG S09LS-1	795	180.90	Not Efficient
2	Head of Transportation and Drainage Sub Department	Panasonic CS-PC9MKH	865	196.83	Not Efficient
3	Head of Public Welfare Sub Department	Panasonic CS-PC9MKH	865	196.83	Not Efficient
4	Head of Government Apparatus and Citizenship Sub Department	Panasonic CS-PC9MKH	865	196.83	Not Efficient

Table 4.30 AC Energy Efficiency of First Floor (Continued)

No.	Room Name	Merk and Type of AC	Input Power (Watt)	Total Energy (kWh/m2/year)	Criteria
5	Head of Physical and Infrastructure Department	Panasonic CS-PC18GKP	1920	246.01	Not Efficient
6	Physical and Public Welfare Staff	LG LP-C508TAO	4800	80.13	Efficient
		LG LP-C508TAO	4800		
7	Singosari	Panasonic CS-PC18PKP	1920	12.40	Very Efficient
		Panasonic CS-PC18PKP	1920		
8	Head of Public Welfare and Government Apparatus Department	Panasonic CS-C12HKH	1150	94.44	Efficient

- AC Energy Efficiency of Second Floor

The comparison between the total energy of air conditioners on the second floor and the standard of ECI is shown in the table 4.27 below.

Table 4.31 AC Energy Efficiency of Second Floor

No.	Room Name	Merk and Type of AC	Input Power (Watt)	Total Energy (kWh/m2/year)	Criteria
1	Head of Agriculture, Marine, and Tourism Sub Department	LG S09LS-1	795	181.49	Not Efficient
2	Head of Business Development Sub Department	Panasonic CS-C18JKP	590	97.92	Efficient
3	Head of General and Staffing Sub Section	Panasonic CS-PC7PKJ	595	87.39	Efficient
4	Head of Finance Sub Section	Mitsubishi SRK09CRP-S3	925	138.99	Not Efficient
5	Head of Work Plan Arrangement Sub Section	Mitsubishi SRK09CRP-S3	925	144.92	Not Efficient
6	Secretariat and Economy Staff	Panasonic CS-C18JKP	590	47.33	Very Efficient
		Panasonic CS-C18NKP	1750		
		Panasonic CS-C18NKP	1750		

Table 4.32 AC Energy Efficiency of Second Floor (Continued)

No.	Room Name	Merk and Type of AC	Input Power (Watt)	Total Energy (kWh/m2/year)	Criteria
7	Head of Economy Department	Mitsubishi SRK09CRP-S3	925	82.81	Efficient
8	Borobudur	Panasonic CS-PC18PKP	1920	24.54	Very Efficient
		Panasonic CS-PC18PKP	1920		
9	Waiting Room	Panasonic CS-C18JKP	590	39.33	Very Efficient
10	Secretary	LG S18LG-2	1800	170.39	Not Efficient
12	Head of Bappeko	Panasonic CS-PC18GKP	1920	65.63	Efficient
		Panasonic CS-PC18GKP	1920		

- AC Energy Efficiency of Third Floor

  The comparison between the total energy of air conditioners on the third floor and the standard of ECI is shown in the table 4.28 below.

Table 4.33 AC Energy Efficiency of Third Floor

No.	Room Name	Merk and Type of AC	Input Power (Watt)	Total Energy (kWh/m2/year)	Criteria
1	Transit	LG S18LG-2	1800	98.19	Efficient
2	Suramap	Mitsubishi SRK09CRP-S3	925	190.17	Not Efficient
		Panasonic CS-C12HKH	1150		
3	Penataran	AUX ASW-184/EA	2080	6.72	Very Efficient
4	Clinic 1	Panasonic CS-PC18PKP	1920	118.58	Less Efficient
5	Clinic 2	Panasonic CS-PC9MKH	865	102.33	Less Efficient
6	Prambanan	Panasonic CS-PC18GKP	1920	6.07	Very Efficient
		Panasonic CS-C12HKH	1150		
7	Scheme (Pola)	LG LP-C508TAO	4800	24.03	Very Efficient
		LG LP-C508TAO	4800		
		LG LP-C508TAO	4800		
		LG LP-C508TAO	4800		

Table 4.34 AC Energy Efficiency of Third Floor (Continued)

No.	Room Name	Merk and Type of AC	Input Power (Watt)	Total Energy (kWh/m2/year)	Criteria
		Panasonic CS-PC18GKP	1920		
		Panasonic CS-PC18GKP	1920		
		Panasonic CS-PC18GKP	1920		
		Panasonic CS-PC18GKP	1920		

4.5.2 *Analysis of AC Energy Efficiency*

After it is known that the cooling need of most rooms are fulfilled, further analysis should be conducted whether the existing air conditioners already use the energy efficiently. If the energy consumption intensity is lower than 100.8 kWh/m^2/year, the usage of air conditioners can be categorized as efficient. On the other hand, if it is more than 100.8 kWh/m^2/year, it is already less efficient. Furthermore, if the ECI is higher than 133.2 kWh/m^2/year, it is categorized as not efficient.

Based on the standards mentioned, it is shown that not all existing air conditioners are efficient in using energy. For example, the air conditioner with 794 watt of input power is categorized as not efficient for Head of Environment and Spatial Sub Department room. It should use air conditioner with lower input power or an eco-friendly one. There are 10 of 27 rooms in Bappeko which are categorized as not effective and 2 rooms are categorized as less effective. The rooms may be comfortable for the users – in this case, the users are employees in Bappeko – because the required cooling capacity is already covered by the existing air conditioners, but it is not in line with the green building.

Very efficient rooms in Bappeko are influenced by the usage of its rooms. The rooms categorized as very efficient are mostly meeting rooms. It is because the rooms are not used for the whole working hours, just once in a while when the meeting is conducted. The duration of the meeting is also not taking the whole day. Typically, it is finished for 2 until 3 hours. The examples are Singosari room which is over capacity, but it is categorized as very efficient. It happens because the cooling load calculation does not consider the energy consumption, while ECI consumption does not consider number of people, etc. It is still tolerable if the room is over capacity, but it uses energy efficiently.

In addition, the behavior of users and the maintenance frequency also affect the energy efficiency in using air conditioners. If the air conditioners are well-monitored and given routine maintenance, their lifetime will be long and still be functioning well. The increasing of the energy consumption should be the indicator that the air conditioners need to be repaired or even be replaced. However, if the current air conditioners already consume big energy, the increasing of the energy consumption cannot be the indicator. With this existing condition, the need of air conditioners in Bappeko is fulfilled and there should be no reason to add them more.

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CHAPTER V
PROPOSED PROCEDURES FOR AIR CONDITIONERS NEED ANALYSIS

This chapter contains the proposed procedures for the need analysis of air conditioners according to the previous evaluation of existing condition.

5.1 Proposed Procedure with ECI

It is realized that not all employees in Surabaya City Government are aware and understand about air conditioners. In order to support Surabaya as green-eco city, well usage and management of air conditioners will help a lot because the usage of air conditioners mostly contributes to energy consumption in buildings. For novice people who do not really pay attention to air conditioners, who only turn them on to cool the room, a guidance will be useful as the reference in using and managing air conditioners. Therefore, a simple methodology is made to be proposed as the guidance especially in need analysis of air conditioners.

The procedure is created based on GBAA criteria, specifically energy consumption intensity (ECI) under Energy Efficiency and Conservation (EEC) criteria. The need analysis of air conditioner is conducted according to the energy that is consumed by air conditioners. The selection of air conditioners will focus on the input power they need. It is known that to use energy effectively, the energy consumption of air conditioners has to be lower than 100.8, or it is rounded down to 100 kWh/m^2/year. This number will be the standard in deciding the need of air conditioners. There are some steps in this need analysis to be followed which are visualized as flowchart on Figure 5.1.

The variables needed in this procedure are only the dimension of the room and the operating time of air conditioners in a year. Then, the calculation based on ECI is used to process those variables which produce the required input power of air conditioners.

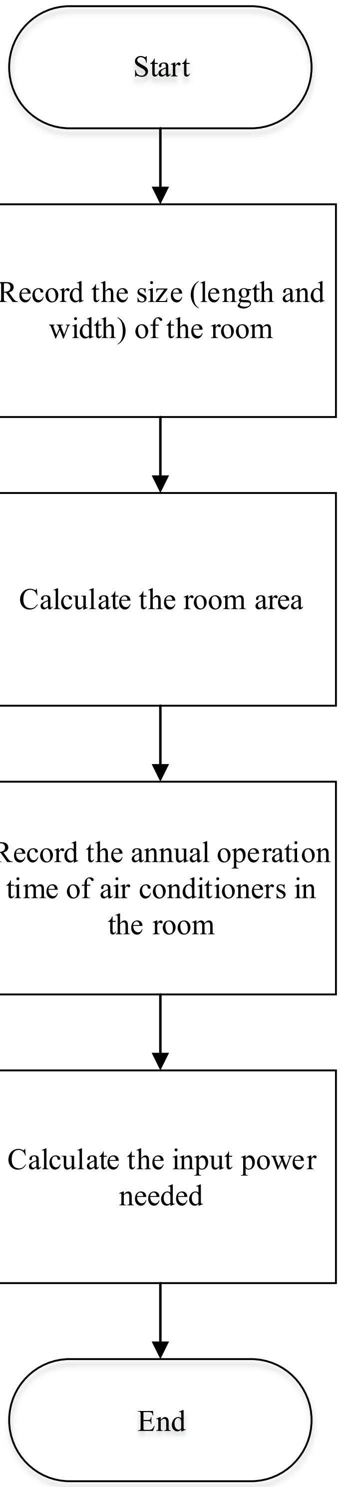

Figure 5.1 Flowchart of Proposed Procedure with ECI

An Excel template is also created for Surabaya City Government to ease the calculation. The Excel template is a table form that is shown as Table 5.1 below. The user only needs to fill the green cells and the output will be directly shown in the orange cells. The formulation used is the opposite of calculating the total energy in previous chapter. 100 kWh/m^2/year becomes the starting point as the limit of energy efficiency as determined before. It is multiplied by the room area, then it is divided by the operating time of air conditioner in a year. The result should be multiplied by 1000 to convert it into Watt unit. In the end, the amount of energy resulted becomes the reference in choosing air conditioner. The air conditioner should have input power as big as the result or even lower than the result.

Table 5.1 Excel Template for ECI Calculation

Room Length (m)	Room Width (m)	Room Area (m^2)	Operating Time of Air Conditioners (hr/year)	The Energy/Input Power Limit (Watt)
		0		0
		0		0
		0		0
		0		0
		0		0
		0		0
		0		0
		0		0
		0		0

This procedure seems simple and easy because it only has two variables needed. It is mostly focused on finding the air conditioners with the efficient energy. However, this calculation does not consider other factors in air conditioning, such as number of people, size of glass window, etc. This procedure is suitable for general office rooms with normal or ordinary condition, for example the head of Bappeko room. If number of people really matters, or other factors also influence, the next methodology can be an option to conduct the need analysis of air conditioners.

5.2 Proposed Procedure with Cooling Load Calculation

Cooling load calculation has long and a lot of steps to be done and it is quite complicated for novice people who are not expert in architecture, green building, etc. This procedure is the same with the methods to calculate cooling load in previous chapter, the user needs to follow those steps from calculating building sensible load, internal heat load, and ventilation and infiltration load. Every variable should be recorded first and SKPDs should have a good recording management. The procedure is shown as flowchart in the Figuer 5.2 below.

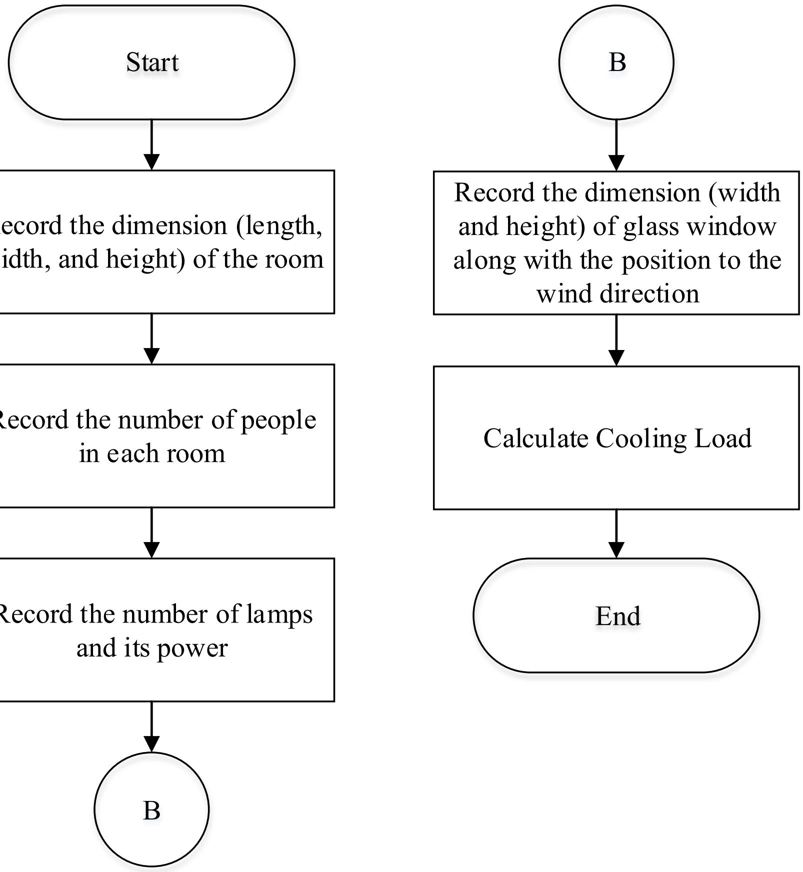

Figure 5.2 Flowchart of Procedure with Cooling Load

Recording so many variables already becomes a difficulty in using this procedure. It is what makes this procedure more detailed and able to give more accurate output based on the real condition of environment. The formulation to calculate cooling load is much complicated compared to the ECI calculation. A simple Excel-based calculator is created to face this kind of problem in this need analysis. The display of the calculator is shown in the Figure 5.3 below.

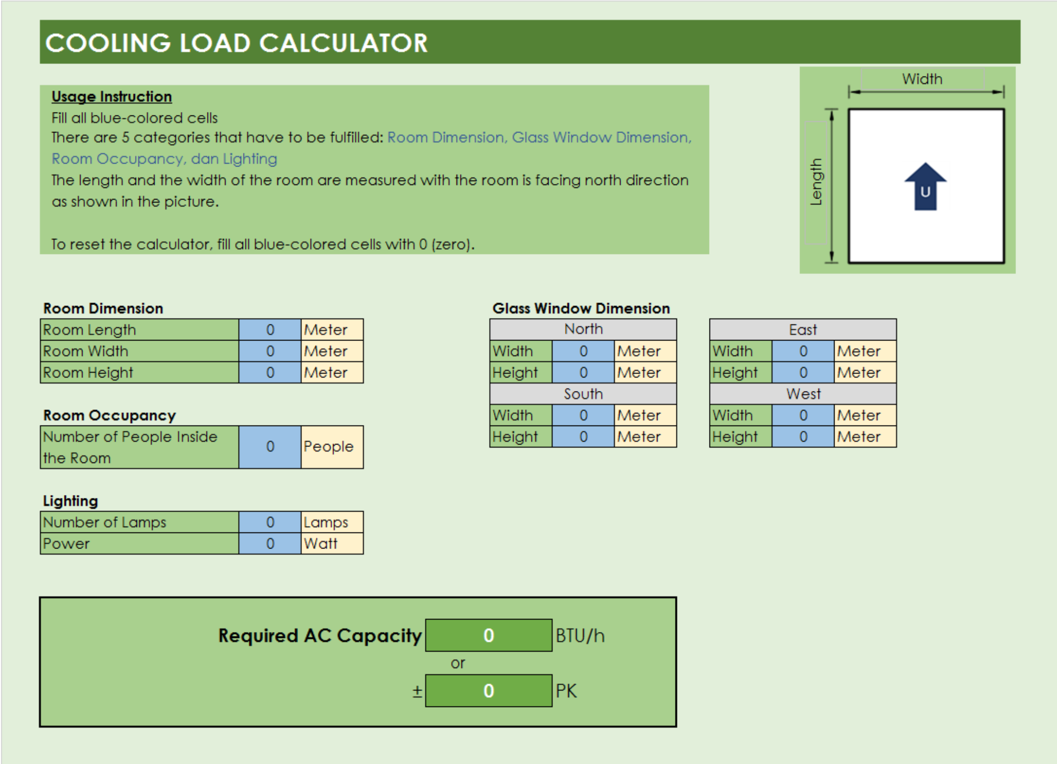

Figure 5.3 Cooling Load Calculator Display

All variables that have been collected and recorded can be directly inputted into this calculator. The capacity of air conditioner that is required will be produced in the unit of BTU/h or PK, which are the common units for air conditioners. This calculator is still a primary basic design that has not been perfect. This calculation is still limited to be used for only one room and cannot be used directly for the whole building. The output is also still in cumulative, it can still be developed to produce advanced output, such as what type of air conditioners with how many capacity, and others. If this calculator can be improved and developed, it will be really useful especially for Surabaya City Government to conduct its need analysis of air conditioners so the air conditioners that are used have sufficient cooling capacity without consuming excessive energy.

5.3 Comparison between ECI and Cooling Load Calculation

ECI calculation and cooling load calculation are obviously different looking at the details that are considered. Taking example with the calculation of rooms on the first floor, the comparison between ECI and Cooling Load Calculation is conducted.

Table 5.2 The Result of Cooling Load Calculation

No.	Room Name	Cooling Load (BTU/h)
1	Head of Environment and Spatial Sub Department	1032.40
2	Head of Transportation and Drainage Sub Department	2179.87
3	Head of Public Welfare Sub Department	2145.87
4	Head of Government Apparatus and Citizenship Sub Department	2145.87
5	Head of Physical and Infrastructure Department	5682.56
6	Physical and Infrastructure Staff	31838.58
7	Singosari	17023.39
8	Head of Public Welfare and Government Apparatus Department	3050.80

Table 5.3 The Result of ECI Calcualtion

No.	Room Name	The Energy/Input Power Limit (Watt)	ECI Result (Btu/h)
1	Head of Environment and Spatial Sub Department	439.462	1499.443
2	Head of Transportation and Drainage Sub Department	439.462	1499.443
3	Head of Public Welfare Sub Department	439.462	1499.443
4	Head of Government Apparatus and Citizenship Sub Department	439.462	1499.443
5	Head of Physical and Infrastructure Department	780.450	2662.895
6	Physical and Public Welfare Staff	8662.500	29556.450
7	Singosari	30975.676	105689.005
8	Head of Public Welfare and Government Apparatus Department	880.492	3004.240

The energy resulted in ECI calculation is converted into BTU/h unit by multiplying it with the coefficient of 3.142. By the formulation in Excel, the standard deviation between the results are calculated. The value of standard deviation for each calculation is shown in Table 5.4 below.

Table 5.4 Standard Deviation Result

SD of ECI Result	SD of Cooling Load Result
36566.5	**10891.52**

It is shown that with Energy Consumption Intensity calculation, the standard deviation is approximately three times higher than the standard deviation of cooling load calculation. It means that the value that is resulted by ECI calculation is far from the average. It also means that the result is not really accurate compared to do the need analysis with cooling load result. It is obvious that cooling load calculation has more variables to be considered, but it does not consider about the energy efficiency. However, if the cooling capacity is lower, it is highly possible to spend low energy. By this comparison, the cooling load calculation seems to be more accurate. Each of calculation has the strength and the weakness which can still be used according to the need in the real field.

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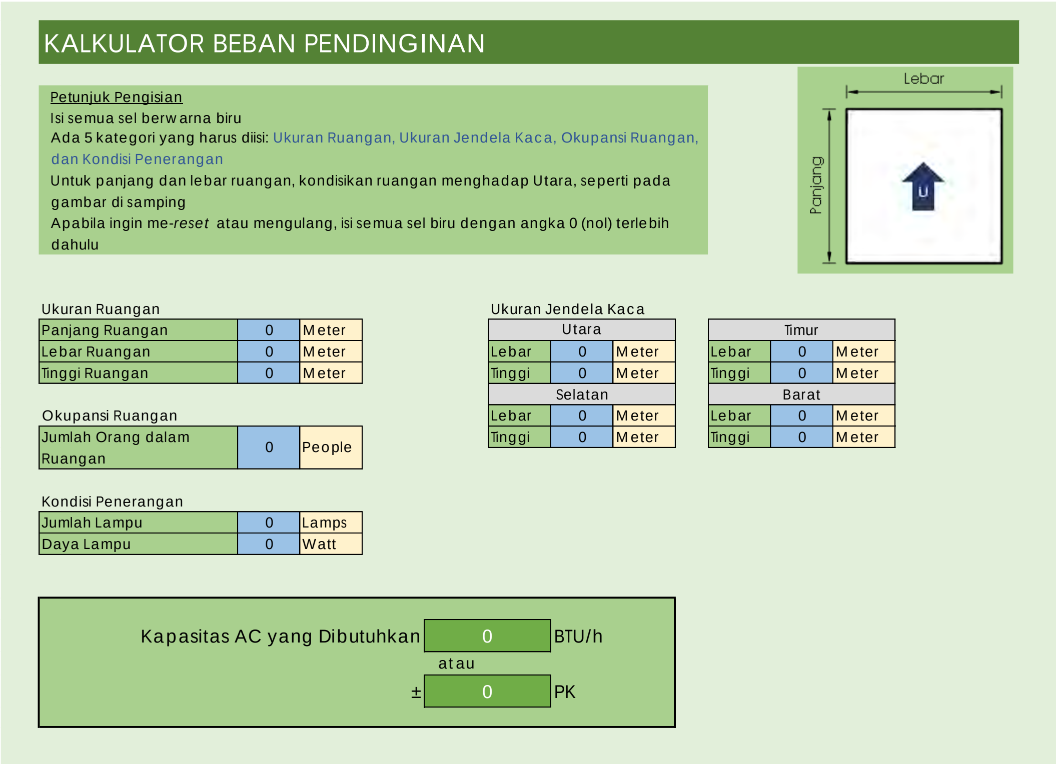
APPENDIX

Appendix 1 *Usulan Prosedur untuk Analisa Kebutuhan* Air Conditioner

Prosedur Analisa Kebutuhan AC dengan Perhitungan Beban Pendinginan

Prosedur analisa kebutuhan ini menggunakan perhitungan beban pendinginan untuk mengetahui kapasitas AC yang dibutuhkan. Data-data awal perlu dikumpulkan agar dapat menghitung beban tersebut. Berikut prosedur analisa kebutuhan AC dengan perhitungan beban pendinginan:

1. Ukuran volum ruangan perlu dicatat. Ukuran tersebut mencakup panjang, lebar, dan tinggi ruangan.
2. Kemudian, mencatat jumlah orang yang berada di dalam ruangan. Dalam hal ini, orang-orang yang dihitung adalah staf atau karyawan tetap yang memang menghabiskan waktu kerjanya di dalam ruangan tersebut.
3. Berikutnya, mencatat jumlah lampu di dalam ruangan beserta dengan dayanya (dalam Watt).
4. Mencatat ukuran jendela kaca yang terdapat dalam ruangan. Ukuran tersebut hanya mencakup tinggi dan lebar. Apabila jendela tersebut tertutup gorden tebal sehingga minim cahaya yang masuk, maka jendela tidak dianggap. Ukuran jendela dicatat per sisi dinding berdasarkan arah mata angin; utara, selatan, barat, atau timur.
5. Langkah terakhir adalah menghitung beban pendinginan dengan data-data yang telah dikumpulkan. Untuk mempermudah perhitungan, cukup isikan data-data tersebut ke dalam kalkulator beban pendinginan dengan format Excel. Tampilan kalkulator tersebut seperti pada gambar di bawah ini.



KALKULATOR BEBAN PENDINGINAN

Petunjuk Pengisian
Isi semua sel berwarna biru
Ada 5 kategori yang harus diisi: Ukuran Ruangan, Ukuran Jendela Kaca, Okupansi Ruangan, dan Kondisi Penerangan
Untuk panjang dan lebar ruangan, kondisikan ruangan menghadap Utara, seperti pada gambar di samping
Apabila ingin me-*reset* atau mengulang, isi semua sel biru dengan angka 0 (nol) terlebih dahulu

Ukuran Ruangan

Panjang Ruangan	0	Meter
Lebar Ruangan	0	Meter
Tinggi Ruangan	0	Meter

Okupansi Ruangan

Jumlah Orang dalam Ruangan	0	People

Kondisi Penerangan

Jumlah Lampu	0	Lamps
Daya Lampu	0	Watt

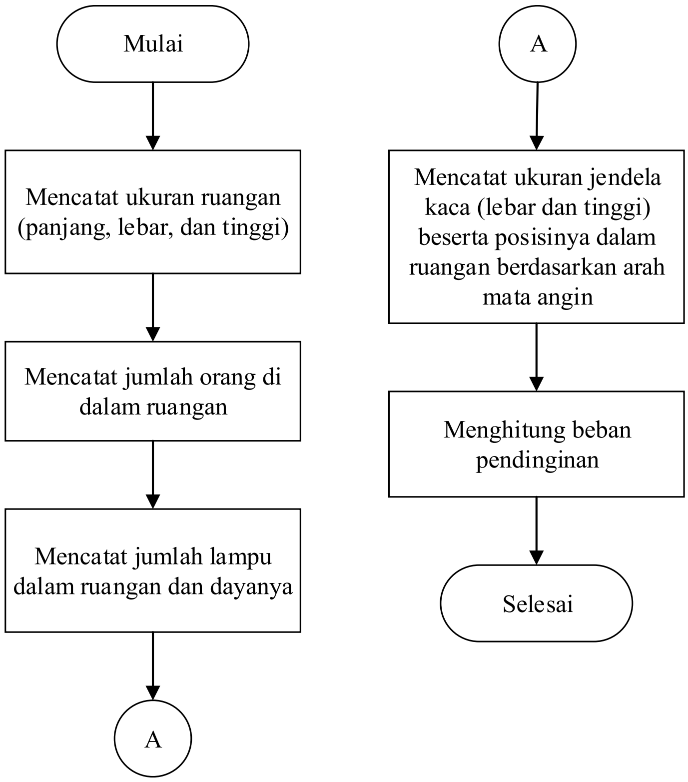
Ukuran Jendela Kaca

Utara			Timur		
Lebar	0	Meter	Lebar	0	Meter
Tinggi	0	Meter	Tinggi	0	Meter
Selatan			Barat		
Lebar	0	Meter	Lebar	0	Meter
Tinggi	0	Meter	Tinggi	0	Meter

Kapasitas AC yang Dibutuhkan 0 BTU/h
atau
± 0 PK

Setelah menghitung beban pendinginan, diketahui maksimum kapasitas AC yang dibutuhkan untuk ruangan tersebut dalam unit BTU/jam atau dalam PK. Apabila tidak ada AC di ruangan tersebut, berarti kapasitas total AC yang dibutuhkan sesuai dengan hasil perhitungan. AC yang dipilih tidak boleh memiliki kapasitas melebihi angka tersebut. Apabila sebelumnya telah terpasang AC dalam ruangan tersebut dan masih berfungsi dengan baik, hasil perhitungan dikurangi dengan total kapasitas AC eksisting. Hasil pengurangan adalah kapasitas total AC yang dapat ditambahkan apabila ingin membeli AC baru. Akan tetapi, apabila hasil pengurangan itu negatif atau kapasitas AC eksisting sudah melebihi hasil perhitungan, maka tidak diperbolehkan membeli AC baru karena sudah *over capacity*.

Prosedur analisa kebutuhan ini dirangkum dalam bentuk *flowchart* seperti pada gambar di bawah ini.



Prosedur ini terperinci karena data inputnya yang cukup banyak. Akan tetapi, karena langkah-langkahnya yang rumit dan data-data yang diperlukan cukup sulit, prosedur ini lebih baik diimplementasikan untuk ruangan-ruangan kantor Pemerintah Surabaya yang memberi pelayanan umum kepada masyarakat. Ruangan-ruangan tersebut memerlukan perhitungan yang lebih detail karena banyaknya orang yang datang dan memerlukan kenyamanan pendinginan yang sebisa mungkin dipenuhi.

Prosedur Analisa Kebutuhan AC dengan Perhitungan Intensitas Konsumsi Energi (IKE)

Prosedur analisa kebutuhan ini menggunakan perhitungan Intensitas Konsumsi Energi (IKE). Berdasarkan Permen ESDM No. 13 Tahun 2012, dapat disimpulkan bahwa standar efisiensi konsumsi energi untuk penggunaan AC pada Gedung Kantor adalah sebagai berikut.

Kriteria	Konsumsi Energi AC (kWh/m^2/tahun)
Sangat Efisien	<61,2
Efisien	61,2 – 100,8
Kurang Efisien	100,8 – 133,2
Boros	>133,2

. Oleh karena itu, penggunaan AC sebaiknya tidak melebihi batas efisiensi dari IKE. Dalam prosedur ini, digunakan standar IKE sebesar 100 kWh/m^2/tahun (sebagai pembulatan dari 100,8). Untuk mengevaluasi penggunaan AC eksisting di Bappeko, perlu didata power input dari setiap AC. Power input ini merupakan energi yang dibutuhkan untuk mengoperasikan AC. Berikut prosedur analisa kebutuhan AC dengan perhitungan IKE:

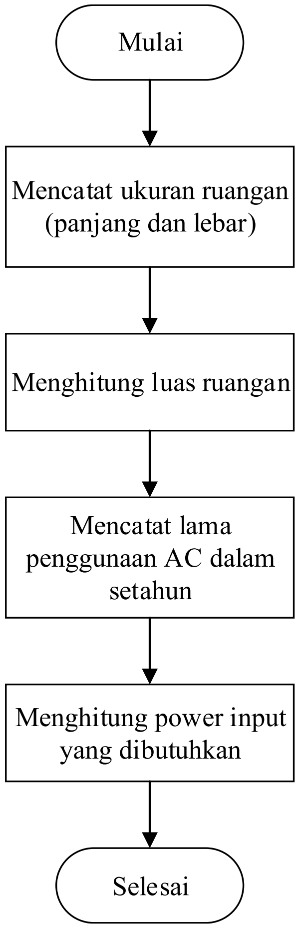
1. Ukuran ruangan perlu dicatat. Ukuran tersebut hanya mencakup panjang dan lebar ruangan.
2. Kemudian, dari ukuran ruangan yang telah dicatat, dihitung luas ruangan.
3. Mencatat lama penggunaan AC dalam setahun. Dapat digunakan lamanya jam kerja sehari dikali dengan hari kerja dalam setahun. Khusus untuk ruang rapat, perlu dicatat terperinci kapan saja ruangan tersebut digunakan. Karena saat ruangan digunakan, AC pasti juga dioperasikan.
4. Menghitung power input yang dibutuhkan. Luas ruangan dikalikan dengan 100 (standar efisiensi yang ditetapkan sebelumnya) dan 1000

(pengubah dari kilowatt) kemudian dibagi dengan lamanya jam penggunaan dalam setahun. Untuk mempermudah perhitungan, cukup isikan data-data tersebut ke dalam *template* Excel kalkulator IKE. Tampilan kalkulator tersebut seperti pada gambar di bawah ini.

Kalkulator IKE

Panjang Ruangan (m)	Lebar Ruangan (m)	Luas Ruangan (m2)	Lama Penggunaan AC (jam/tahun)	Batas Power Input yang Direkomendasikan (Watt)
4	3	12	1880	638.298
		0		#DIV/0!
		0		#DIV/0!
		0		#DIV/0!
		0		#DIV/0!
		0		#DIV/0!
		0		#DIV/0!
		0		#DIV/0!

Hasil yang didapatkan adalah batas power input yang direkomendasikan dalam satuan unit Watt. Apabila akan membeli AC baru, power input tidak boleh melebihi batas yang direkomendasikan. Perhitungan ini hanya berdasarkan efisiensi energi, tidak mempertimbangkan variabel lain seperti jumlah orang, dan sebagainya sehingga hasil akhirnya tidak seakurat prosedur analisa kebutuhan dengan perhitungan beban pendinginan. Prosedur ini lebih sesuai digunakan untuk ruangan-ruangan kantor biasa. Rangkuman prosedur ini dapat dilihat dalam bentuk *flowchart* seperti gambar di bawah ini.


Mulai
Mencatat ukuran ruangan (panjang dan lebar)
Menghitung luas ruangan
Mencatat lama penggunaan AC dalam setahun
Menghitung power input yang dibutuhkan
Selesai

CHAPTER VI
CONCLUSIONS AND SUGGESTIONS

This chapter presents the conclusions and suggestions that can be obtained from the result of research that has been explain in previous chapters.

6.1 Conclusions

The conclusions that can be identified from this research are:

1. Most of the usage of air conditioners in Bappeko exceeds the necessary cooling capacity. It means that the cooling need is mostly fulfilled, but based on the standards from GBAA criteria, it is shown the energy usage is not all efficient. There are some rooms that categorized as very efficient, which are Secretariat and Economy Staff room and meeting rooms. The cooling capacity should be between these results. Then, there should be no reason to add or purchase new air conditioner because the cooling need has been fulfilled.
2. In conducting the need analysis of air conditioners, there are some variables that need to be considered. In order to implement the green building concept, it is necessary to use energy efficiently which means that the energy consumption of the air conditioner should be considered. The existing condition also needs to be updated so the air conditioners can fulfill the cooling capacity needed. The factors that gives influence the most in determining the air conditioners need are number of people in the room and dimension of glass window.
3. There are two procedures that are proposed to conduct air conditioners need analysis. Each procedure has its own strength and weakness, but the usage depends on the real need in the field. For SKPDs that have rooms for offering public services, it is recommended to use the cooling load calculation as the reference in order to be more accurate in determining the need of air conditioners. However, it is not necessary and too

complicated to use it for the normal office rooms, like meeting rooms, so this kind of rooms better use the ECI calculation as reference.

4. The need analysis procedures that are produced in this research can be implemented not only in Bappeko but also other office buildings. The calculation is already absolute for office buildings type. However, it is not verified to be used on other types of buildings.

6.2 Suggestions

The suggestions that can be given for this research are:

1. The Surabaya City Government, especially Bappeko where this pilot research taken place, needs to have the record of existing condition, both for the condition of the room and the air conditioners, and update it once in a while. The record of air conditioners maintenance is highly suggested.
2. The cooling load calculator needs to be developed and improved in order to be more useful not only for Surabaya City Government, but also other parties who have buildings as well.

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During her 4-years of study, she was active joining some organizations. In sophomore year, she was a staff in Industrial Engineering student association (HMTI). Then, she started becoming a volunteer of ITS International Office in the beginning of her junior year. She had experiences in taking care of ITS international students and being a committee for short programs with international participants from around the world. In final year, she joined a student internship for one week in University of Malaya, Malaysia and she took a leadership and culture course in a winter school program at Istanbul Aydin University, Turkey.

Not only active gaining experiences in organizations, but she was also active learning something new through travelling. Exploring new places became her interest after she joined Mahapati, a hiking and outdoor club in Industrial Engineering ITS. She has explored a lot of cities, specifically in Java-Lombok, hiked some mountains, and visited many beaches and other tourism places during her spare time between academics and organizations. All journeys she had makes her interested in nature conservation, green buildings, and sustainable manufacturing.

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